# LEVEL MEASURING SET PSM-5

Frequency range : 10 kHz to 36 MHz

Service Manual BN 444

1.8.68 Bi

0.15.3.74 2109 UN v. 1594

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# 1. INTRODUCTION

Due to the advanced design and the interaction between the three individual units of the complete measuring set, it is not easy to establish the location of a fault. The section "DESIGN AND THEORY OF OPERATION" of the Operating Manual and especially section 2 "DETAILED INDIVIDUAL SUBUNIT DESCRIPTION" of this Maintenance Manual, serve to aquaint the user with the individual circuits of the complete measuring set.

Section 4, "FAULT LOCATION" of this maintenance manual gives instructions for systematic fault tracing from circuit to circuit by means of voltage tests and oscilloscop displays. Section 5 of this manual, "CHECKING AND ALIGNMENT" is also an aid in the above task, since this section explains the main tests and alignment tasks required of the individual units.

Section 6 contains all the oscilloscope displays required for a functional check of each individual instrument. These illustrations are also referred to in the section "FAULT FINDING".

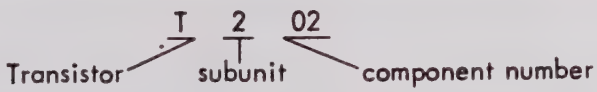
The section "MAINTENANCE AND REPAIR" contains instructions pertaining to the care of the complete measuring set.

The individual subunits referred to in this manual are numerically coded:

e.g. (2) Control Oscillator.

Each component located in this unit has the number 2 as its initial digit. Each component is further defined by two following digits, such as 01 in resistor R 201 or inductance L 201.

Thus, if transistor 02 to be found in circuit diagram (2) the coding will be as follows:




When ordering replacements, full information must include the order number of the measuring instrument, the serial number of the instrument and the full component number: e.g. BN 241 No. 36737 D T 202

# 2. DETAILED INDIVIDUAL SUBUNIT DESCRIPTION

## 2.1. Control Oscillator RWO-5

### 2.1.1. Control Oscillator (2) and Control Frequency Buffer (1)

The Generator PS-5 and the Receiver PM-5 derive the control signal required for synchronous tuning from the control oscillator via the buffer stage of the RWO-5. A frequency of 69 MHz serves as the fixed frequency for the generator and as the first intermediate frequency of the receiver. The frequency range of the control oscillator thus extends from 69.01 to 105 MHz corresponding to the signal frequency range of the measuring set from 10 kHz to 36 MHz. The control voltage for the generator and receiver is $U_{rms}$ = 0.5 V (load impedance = 75 Ω)

The full oscillator frequency determining capacitance consists of varicap diodes GI 201 to GI 208, whose capacitance is adjusted by means of the output voltage of the linearization circuit (7).

The resonant inductance consists of a wire loop accomodated in a metal housing and tuning is achieved by means of a metal tab. The oscillator output is fed to the pre-amplifier T 110/T 111 via the buffer stage T 202, which has no retro-action and which presents a resistive load to the oscillator. The subsequent output stage T 101/ T 102 has an output impedance of 75 Ω and presents a non-load voltage of 1 V to output sockets Bu 103 and Bu 106.

The attenuated signal of the output stage is fed to frequency converter 3 at socket Bu 107 with an amplitude of 0.1 V at 75 Ω output impedance.

A DC voltage is derived by the rectifier circuit GI 101/GI 102 from the final stage output of T 101/T 102, and is compared with a reference voltage (voltage at P 101) in amplifier stage T 103. The output current of T 103 determines the emitter current of the transistor oscillator T 201 and thus the oscillator amplitude. This results in a near constant output signal throughout the whole frequency range.

Adjustment of potentiometer P 101 alters the reference voltage and as a result the oscillator amplitude.

The filter networks mounted on circuit boards 241-X and 241-Y of the control oscillator decouple the individual stages and filter the supplied operating voltage.

## 2.1.2. Function of coil L 103 at the Control Frequency Output for the Receiver

The coil L 103 is to be found between the sockets Bu 104 and Bu 105. It consists of a screened RF-cable wound on to a pot core.

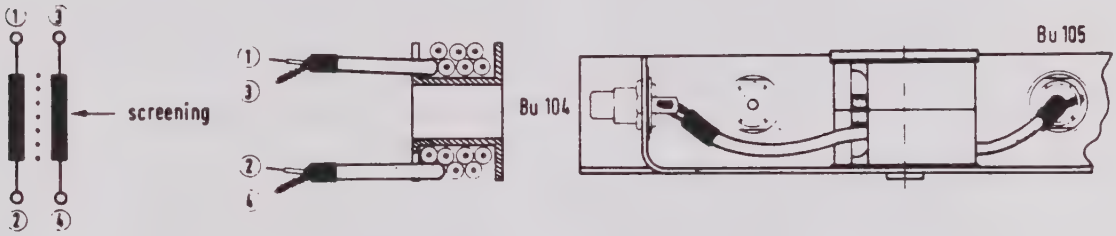



Fig. 1

The coil is designed to fulfill two tasks:

1) It must present a sufficiently high mutual impedance of $\geqq 7\ \Omega$ between the equal-potential chassis of the RWO-5 and PS-5 to the Receiver portion PM-5, throughout the measuring frequency range of 10 kHz to 36 MHz. This is of importance when testing high loss objects since a ground shunt to the test object between generator and receiver would bring errors into the measurement.

   The cable screening (turns 3 to 4) forms the desired impedance. The output current is thus forced to flow from the generator via the test object to the receiver and to return only via test object ground to the generator.

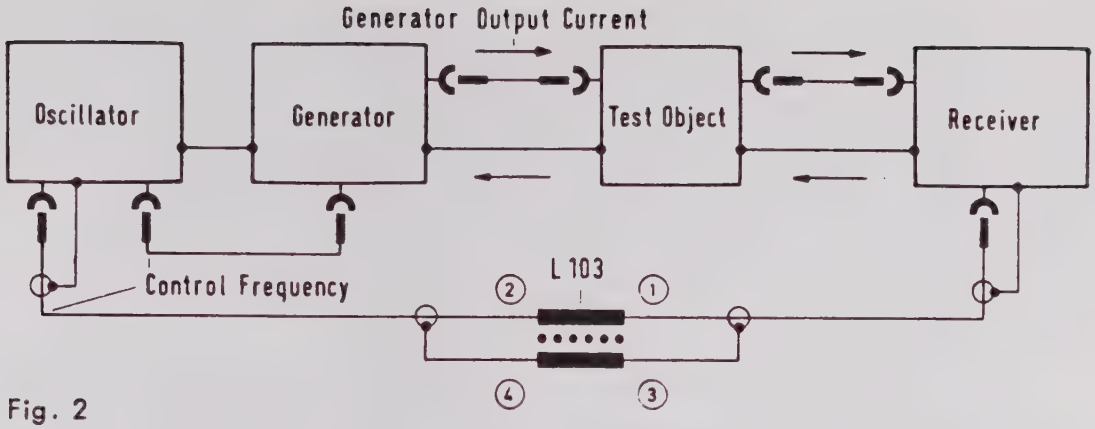



Fig. 2

2) It must at the same time present a low impedance control frequency connection between the Control Oscillator RWO-5 and the Receiver PM-5 so that the interference pick-up is avoided.

The internal and external conductors of the coiled RF-cable form a bifilar winding: i.e. the currents of the two conductors are arranged to oppose each other thus cancelling their effects.

This results in the same low-impedance for the control frequency as would be presented by a non-coiled cable.

## 2.1.3. Frequency Converter (3)

The task of this frequency converter is to form a difference frequency from the frequencies of the coarse frequency oscillator and the control oscillator. This difference frequency is required as a reference for the interpolation oscillator frequency. The coarse frequency oscillator signal then assumes the role of the "carrier" and is applied to the buffer stage T 301, located on circuit board 241-Z, at an amplitude of approx. 450 mV.

The input signal with an amplitude of approx. 90 mV is applied to the two buffer stages T 303 and T 304 mounted on circuit board 241-AS.

Since the frequency converter passes the difference frequency to a phase shifting network, it is important that a large amplitude difference be maintained between the residual carrier and the desired output signal to avoid disturbances during phase shifting. The low-pass filter network comprising L 302/C 305 and L 901/C 901 at the input of the counting discriminator 1 as well as the basic design of the converter meet the above requirement.

The 1 MHz or 100 kHz spikes produced in the phase meter (14) have a retro-action on the converter input (3) via buffer transistors T 1402 and T 1404. This, together with the coarse oscillator frequency or with the control frequency via the converter, may produce undesirable beat frequencies. Two additional buffer transistors T 305 and T 306 are provided to suppress these interference signals.

### 2.1.4. Coarse Frequency Oscillator (4)

The coarse frequency oscillator can be phase-locked. Its frequency range covers 66 to 102 MHz. During tuning, the flywheel swings its frequency into the hold-in range of a sync. circuit which locks the frequency to a multiple of 100 kHz. The frequency setting is indicated on a projected scale having a calibration marker spacing of 100 kHz. Provision is made for locking the oscillator to any one of these markers. The oscillator consists of a three-point circuit with transistor T 401, inductance L 401 and variable capacitor C 407. Feed-back is achieved via a coil tapping and C 404 to the emitter of transistor T 401. The varicap GI 401 serves as the frequency control element.

To achieve this, the phase-meter (14) compares the oscillator signal with the phase position of a 100 kHz square wave voltage and presents the varicap with the voltage required for adjustment to the nominal value.

In the free-running oscillator mode, as selected by switch S 401, the output of the Zener diode GI 402 is applied to varicap GI 401 and is thus biased to 10 V. The frequency locking circuit is then disconnected and the oscillator can be tuned freely. The meter J 2302 receives an additional current corresponding to f.s.d. which in turn indicates the free-running mode of the oscillator.

The oscillator output is applied to frequency converter (3) and phase-meter (14) via two buffer transistors T 402 and T 403. The r.m.s. value is approx. 0.4 to 0.6 V.

Conditions regarding the Stability of the Phase-lock

Frequency deviations due to variations of temperature, shock or other effects must be kept to a minimum to ensure that the oscillator does not wander from the phase-locked condition. This requires a rugged design, a small temperature coefficient and a wide pull-in range. The circuit temperature coefficient is approx. $-3 \times 10^{-5}/^{o}$ C, the pull-in range is approx. ± 12 kHz at 66 MHz and approx. ± 35 kHz at 102 MHz.

## 2.1.5. Auxiliary Oscillator (5)

Due to the operating principle (see functional description of the oscillator RWO-5) the linearizing circuit (7) requires a control current which varies as a linear function of the coarse oscillator frequency. This should then cause the coarse frequency oscillator to be lead by the control oscillator by approx. 3 MHz.

The difficulties of designing a discriminator for the frequency of the coarse frequency oscillator are avoided by providing tuning of the coarse frequency oscillator and an auxiliary oscillator by means of a common tuning capacitor shaft. The auxiliary oscill possesses approximately a thousandth of the coarse oscillator frequency and roughly the same relative frequency variation. This oscillator comprises a three-point circuit consisting of the two transistors (T 501/T 502). The circuit arrangement provides high frequency stability due to its high Q and negligable transistor feedback. By means of DC negative feedback via R 503 optimum current distribution is induced into the differential amplifier T 502/T 503, thus ensuring a reliable oscillation commencement The near-square wave output is brought out across the second half of the differential amplifier T 503 and the transformer Ü 501 at an amplitude of $U_{pp} = 2$ V and drives the limiter of the following circuit.

## 2.1.6. Discriminator for Auxiliary Oscillator (6)

The capacitor combination C 603/C 604 is pulse switched either to 0 V (ground) or -15 V by the transistors T 601/T 602, according to the input signal wave form derived from the auxiliary oscillator. The capacitors C 603 and C 604 are then charged and discharged according to the amplitude swing of this square wave pulse.
The pulsating discharge current is supplied to capacitor C 605 via GI 603. Its DC component is applied to the subsequent linearizing circuit via a low-pass filter network.
To ensure that this current component is reduced with increasing frequency, it is superimposed with a constant current of opposite sense. The sum of these two currents is adjusted to 1 mA at a coarse oscillator frequency of 102 MHz by means of the potentiometer P 601. The constant opposing current is generated by T 603. GI 605 and the base-emitter diode T 603 compensate the opposing current by giving the same temperature dependence as that of the discriminator current effected by the diodes GI 603 and GI 604.
The slope of the discriminator characteristic, i.e. the change in discriminator current as a function of frequency, is proportional to the capacitance of C 603 and the charging current. The design slope of the discriminator is -0.2 mA/MHz. The additional capacitor C 604 is provided for slope alignment when working in conjunction with the linearizing circuit. The low-pass filter network on circuit board 241-AE filters out the control current required for the linearizing circuit to avoid frequency modulation by the auxiliary oscillator frequency.

## 2.1.7. Linearizing Network (7)

The coarse tuning oscillator must drive the control oscillator via the auxiliary oscillator and the following discriminator to ensure that the control oscillator frequency is 3 MHz above the coarse oscillator frequency at all times.
The task of the linearizing network is to convert the discriminator output current into the control voltage required by the control oscillator varicaps. The input current of the linearizing network is a linear function of the frequency, corresponding to the discriminator characteristic. The output voltage must be a function of the characteristic of the varicaps in the control oscillator. At point 4 of the linearizing network, the

maximum output voltage of +19 V is achieved when the control oscillator frequency is 105 MHz and the input current 1 mA. Minimum output voltage of +2.4 V occurs when the frequency of the control oscillator is 69 MHz and the input current 8.2 mA. To avoid spurious modulation of the control frequency, the output voltage of the linearizing network must be maintained highly constant. The control circuit comprising T 704 and T 705 is provided for this purpose.

The input current from point 5 is applied via L 702 to the emitter of T 707 and emerges at T 707 collector reduced by the amount of the base current. For small values of the collector current, diodes GI 706 to 714 are rendered nonconducting, resulting in the voltage at T 707 collector, and thus that at point 4 of the circuit, being determined solely by the voltage drop across R 720 and GI 705.
The voltage divider comprising R 710 to R 719 causes each of the diodes to assume a certain potential. If the collector voltage of T 707 possesses a potential with an amount less that of the diode threshold, this will cause the respective diode to conduct.

In the absence of the diode circuit, the collector voltage of T 707 would fall as a linear function of the increasing input current. The introduction of the diode circuit, however, together with the parallel connection of an additional resistor, effects a reduction of the collector resistance at definite collector voltage values, thus causing a kink in the characteristic curve, showing the collector voltage as a function of emitter current for T 707.
The desired variations of the output voltage is achieved by adjustment at three points of the voltage divider R 710 to R 719. The initial, centre and end portions of the range are adjusted with potentiometers P 701, P 703 and P 704 respectively.
The base voltage of T 707 has been shifted with respect to 0 V by a positive amount equal to the diode threshold by means of GI 704 to ensure that the input (emitter T 707) is not DC biased with respect to 0 V. The control circuit comprising T 701 to T 703 supplies a constant voltage of - 15 V to the auxiliary discriminator and to the auxiliary oscillator itself.
This voltage also causes a constant current to flow via R 705. The control circuit output voltage is adjusted at the emitter of T 704 to compensate the above-mentioned constant current except for the small base current required by T 705. The output voltage is thus determined by the values of the resistors R 704 and P 701 and the current across

R 705. Adjustment of P 702 must always occur prior to adjusting P 701.
The zener voltage of GI 702 is increased by the forward voltage of diode GI 701 (which provides temperature compensation of the emitter-base voltage of T 703) and serves as a reference voltage for the 15 V control circuit. The control circuit compares that portion of its output voltage tapped at P 702 with the reference voltage and adjusts the output voltage correspondingly across the control P 701.
Upon switching-on, it could happen that the collector of T 701 assumes a positive voltage via R 705 thus resulting in no zener voltage, since GI 701 is then rendered non-conducting.
The circuit would then remain in this condition. The diode GI 703 and the resistor R 701 ensure, however, that this condition does not occur. A positive voltage at the collector of T 701 blocks diode GI 703. At the same time, however, current is applied to the zener diode GI 702 via R 701 which then effects a build-up of the zener voltage required to operate the circuit.

### 2.1.8. Frequency and Phase Control Circuit (8)

This circuit has the following tasks:

1) Normally, to sum the control signal currents (outputs from the phase-meter and counting discriminators I and II) and to amplify this sum in a limiter amplifier prior to application to the linearizing circuit.

2) In the sweep mode, the phase control or the frequency and phase control circuit must be capable of being switched-off depending on the sweep width.

When the phase control circuit (Ü 801, Ü 802, GI 803 to 806) is to be switched-off, the contacts of relays rel 803 and rel 801 are opened. The transistor amplifier T 801/T 802 is then only driven by the sum of the output currents from both the counting discriminators (9) and (10) . The sum of the output currents is zero under equal frequency conditions due to the opposite polarity (fed via point 1). In this case the output current at point 11 of the circuit is near zero, whereby under maximum conditions the value is in the region of ± 0.8 mA.
The frequency control circuit is switched-off by opening of contact rel. 802. This is the case when the sweep current is supplied directly to the linearizing circuit via point 3, R 808 and point 11 for the purpose of generating the four largest sweep widths

When the frequency control operates in conjunction with the phase control, the purpose of the former is to provide an accurate adjustment of the control frequency to ensure that it always remains within the locking range of the phase control. This can only be achieved by the frequency control when the characteristics of the two counting discriminators coincide to a large degree.

### 2.1.9. Counting Discriminator I (9)

The task of this discriminator is to convert the difference frequency (control frequency minus coarse oscillator frequency) into a direct current proportional to the frequency. The slope of its characteristic amounts to an average of 1 mA/MHz; its output current is of an opposite polarity (neg. count direction) to that of counter discriminator II (see 2.1.10.). L 901/C 901 complement the low-pass filter of the frequency converter 3
T 901 has the function of a buffer stage and T 902 an amplifier. T 903 and T 904 form an AC coupled limit amplifier, T 905 and T 906 constitute a pulse shaper, comprising two switching stages which operate alternately. These two transistors together with the shunt arrangement of C 912 and C 913 and the diodes GI 903 and GI 904 make up the frequency discriminator, the slope of which is varied by means of C 912. The discriminator operates in a similar manner to the auxiliary oscillator discriminator (6) (see 2.1.6.).

The output signal of the switching stage is applied to the phase control circuit via T 907, this, however, is only the case when point 2.1. of the circuit is switched to +36 V via the contact of relay 801 accomodated in the phase control circuit. Only then are T 907 and GI 905 rendered operative.

### 2.1.10. Counting Discriminator II (10)

The counting discriminator II converts the output signal of the interpolation oscillator into an output current being proportional to the input frequency. Its slope corresponds to that of counting discriminator I, its output current is, however, positive thus resulting in the sum of the output currents of both discriminators being zero when the respective input frequencies are equal.

Since the square wave input signal possesses a sufficient amplitude, a pre-amplifier stage and also the AC coupling of the limit amplifier can here be dispensed with.

In all other respects the circuit arrangement corresponds to that of counting discriminator I.

### 2.1.11. Standard Frequency Buffer (11)

The output of the standard frequency source is applied via the buffer circuit in the correct waveform to the various subunits of the three basic instruments; control oscillator, generator and receiver. The transistor stage comprising T 1101 and T 1102 amplifies and limits the input signal to a voltage of approx. $U_{pp} = 6.5$ V. Alternate switching of the connecting point of both collectors to the emitter potential of either T 1101 or T 1102 is achieved by causing the corresponding transistor to conduct.

The resulting square wave signal is applied to the phase meter 14 via R 1112 and is also fed to the generator PS-5 via an attenuator, comprising resistors R 1111 and R 1113.

The frequency divider network comprising circuits (12a) and (12b) is driven via the buffer stage consisting of T 1103 and T 1104.
The circuit configuration of board 241-AW is responsible for the distribution of the 100 kHz and 10 kHz signals. This circuit also applies the current supply to the frequency divider networks.

### 2.1.12. 10 : 1 Frequency Divider (12)

Two identical 10 : 1 frequency dividers are series connected into the instrument to generate a 10 kHz square wave signal from the 1 MHz standard. The 10 kHz signal has a dual purpose:

1. To effect frequency synchronization of the local oscillators of the receiver PM-5.
2. To generate the input signal required for the tuning indication of the interpolation oscillator.

The 10 : 1 frequency divider comprises 4 consecutive flip-flops and an output buffer. In the simple consecutive switching condition i.e. free-running, the circuit would divide the input frequency in the ratio 16 : 1. It is, therefore, necessary to disturb the normal 'binary' divider cycle to obtain the desired 10 : 1 division.

The circuit operates in such a manner that the positive drive pulse for each flip-flop is not fed directly to the flip-flop input but via diode gates. This allows the reduction of cycle from 16 to 10, which is achieved by blanking one or more driving pulses from the flip-flop and thus jumping several pulses.

The switching cycle is shown in circuit diagram (12) .

It can be seen that the first flip-flop switches quite regularly. The transistors shown to the left in the circuit diagram are conductive. This means that the diode gate GI 1201 of the first flip-flop conducts, whereas GI 1202 blocks. The first positive input pulse will block transistor T 1201 via GI 1201 and thus triggering the first flip-flop. The second input pulse via the now conducting diode gate triggers the first flip-flop back. The positive output pulse at the collector of T 1202 then triggers the second flip-flop into its operative position. The first interruption into the normal operating cycle takes place at the fourth input pulse. The second flip-flop should now be triggered back by the second positive output pulse, however, the diode gate GI 1205 is blocked because of the base emitter potential of T 1205 is held at constant -7.1 V by GI 1204. Diode gate GI 1206 however conducts and thus triggers the third flip-flop into its operative position. This means that a condition is achieved at the fourth input pulse which would normally appear firstly at the sixth input pulse. This means that two strokes have been jumped. The second interruption into the normal operating cycle takes place at the sixth input pulse, where the fourth flip-flop instead of the third flip- flop is triggered into its operative position via GI 1208. This means that four further strokes have been jumped, since this condition is achieved normally firstly at the twelfth input pulse. The rest of the cycle then continues in a regular manner. The tenth input pulse then re-commences the cycle.

The frequency division can therefore be summerized as :

The first flip-flop operates individually and forms a 2 : 1 divider.
The second, third and fourth flip-flop in conjunction with each other form a 5 : 1 divider.

The series connection of both dividers results in a 10 : 1 division. The output-buffer stage has the advantage over a normal collector-base stage by having a quicker charge reversal of C 1217. T 1208 acts as a high-impedance emitter resistance if T 1210 is triggered by a negative voltage step of approx. -1 V to -7 V applied to its

base and if its emitter follows this voltage. T 1210 is initially blocked due to C 1217 charging-up during subsequent reversed voltage gradient. Charging reversal is quickly effected, however, since T 1208 commences to conduct.

## 2.1.13. Standard Frequency Oscillator (13)

This unit comprises:

a) a 2 MHz crystal oscillator with a 2 : 1 frequency divider and a stage designed to switch-off the oscillator when an external standard frequency is used.
b) a two-stage limiter for the output signal.

This oscillator supplies an internal 1 MHz standard frequency, the accuracy of which determines the frequency accuracy of the measuring set.
This oscillator, comprising transistors T 1301/T 1302, operates as a Colpitt's oscillator. The crystal is not operated at its series resonance but between the series and parallel resonance and thus acts as an inductance. Coupling of the two transistors T 1301 and T 1302 via a common emitter resistor fulfills a dual purpose:

1. Low input capacitance over the whole operating range thus causing the circuit to have little effect on the frequency stability and the simultaneous amplitude limiting.
2. Output voltage free of retro-action.

Use is made of the following two trimmers to effect frequency adjustment in the order of $\pm 50 \times 10^{-6}$ to $\pm 80 \times 10^{-6}$:

$$C\ 1301 : \geqq \pm 35 \times 10^{-6}$$
$$C\ 1305 : \geqq \pm 15 \times 10^{-6}$$

Drift due to ageing, etc. can thus be compensated for. Initial drift due to aging amounts to approx. $1 \times 10^{-7}$ per week.
The crystal oscillator is followed by a 2 : 1 frequency divider in the form of a flip-flop (transistors T 1305/T 1307). T 1304 supplies the required square-wave signal having a steep leading edge.
The frequency divider output controls a two-stage limiter. The stages, which operate as differential amplifier, are emitter-coupled with respect to AC voltages only, thus enabling a stable DC operating point to be achieved inspite of the tolerances of the individual transistor characteristics. The output of T 1309 is applied to the internal

subunits via socket Bu 1302 at an output impedance of $Z_{out}$ = 75 Ω. T 1310 delivers its DC free output also at an output impedance of $Z_{out}$ = 75 Ω to socket Bu 1303 for connection of external loads.

If the frequency is to be controlled by an external standard frequency applied to socket Bu 1301 instead of the internal crystal oscillator, transistors T 1303/T 1306 will cease to supply DC to the 2 MHz oscillator if the external frequency standard has a DC resistance of ≦ 100 kΩ. The limiter receives its input signal then from T 1308.

### 2.1.14. Phase Meter (14)

The purpose of this circuit is to generate a control voltage for effecting the frequency control of the coarse frequency oscillator. This circuit also supplies signals to the respective meter amplifier (15) to indicate the phase-locked condition. The unit (14) contains a 1 MHz and a 100 kHz phase comparison circuit. The 1 MHz square wave signal is applied to point 2 of the 1 MHz phase comparison circuit, from which a fast narrow switching pulse is formed by the pulse former T 1401/T 1403 for the diode chain comprising GI 1403 to GI 1406. Under quiescent conditions transistors T 1401 and T 1403 are blocked. The input square wave voltage is differentiated via C 1403/ R 1408 and causes T 1403 to conduct. The differentiation of the negative output pulse from T 1403 is achieved by the variable capacitance diode GI 1402. Since this diode was turned on by the bias current via R 1411, the capacitance of GI 1402 required for differentiation is effective only after being sufficiently discharged. The width of the resulting pulse is thus mainly dependent on the discharge time and can be adjusted by means of the bias current. The pulse resulting at transformer Ü 1401 switches on all of the diodes GI 1403 to GI 1406. The instantaneous voltage present at the emitter of T 1404 during conduction (coarse frequency oscillator signal via buffer stage T 1402, T 1404) is thus applied through the low-pass filter R 1414/C 1406 or R 1415/ C 1406 to the output at point 5. The phasing of the oscillator signal with respect to the switching pulse determines the output voltage wave-form .

Under constant phase conditions and if the oscillator is phase-locked, a positive or negative DC voltage is generated. If the oscillator is not phase-locked, an AC voltage results. The frequency components of this voltage consist of the difference frequencies between the coarse oscillator frequency and all multiples of 1 MHz.

In order to obtain an output signal with an amplitude independent of the oscillator frequency, it is necessary for the conducting period of the diodes to be shorter than one half cycle of the highest oscillator frequency (102 MHz). If the switch-on time corresponded to one cycle of the oscillator frequency, no output signal would result. During the pulse intervals under 'worst case' conditions, the diodes would cut off the peak-to-peak oscillator voltage at the emitter of T 1404. This would result from the threshold of the series-connected diodes 1 N 914 (GI 1403/GI 1404 of GI 1405/ GI 1406). The series arrangement of R 1414 and R 1415 presents a load to the transformer and hinders the formation of interference transients by the transformer which would otherwise occur under no-load during the pulse intervals.

The 100 kHz phase comparison circuit has the following differences with respect to the circuit previously described:

The output voltage resulting from the phase comparison is superimposed on a bias voltage of -10 V. This voltage is presented to the circuit at point 6 from the zener diode GI 402 in the coarse frequency oscillator.

Positive feed-back through C 1413 to the pulse shaper input is provided to steepen the leading edge of the output pulse. R 1424 prevents the output impedance of the controlling 10 : 1 frequency divider (12a) from affecting the feed-back..

The voltage resulting at point 7 of the circuit sets the coarse tuning oscillator frequency to the desired value by means of the variable capacitance diode GI 401 in the coarse tuning oscillator.

## 2.1.15. Lock-In Indicating Amplifier (15)

This circuit receives the phase-meter output signals and indicates, on meter J 2302, whether the coarse frequency oscillator is locked and whether its frequency is a multiple of 1 MHz or 100 kHz.

As with the phase-meter it is useful to discriminate between a 100 kHz channel (input at point 1) and a 1 MHz channel(input at point 5) when discussing the lock-in indicating amplifier. A discriminator is connected to the 100 kHz channel output, whereas a rectifier circuit for the meter J 2302 is present at the output of the 1 MHz channel.

In the phase-locked mode no AC signal is present at the 100 kHz channel input and thus the discriminator circuit output does not supply DC to the meter circuit.

The result of this is that the phase-locked mode is indicated. In the absence of a DC output in the 1 MHz channel (the rectifier circuit has no DC output when the coarse frequency oscillator frequency is a multiple of 1 MHz), the meter indicates the 1 MHz marker. For all other phase-locked frequencies the 1 MHz channel has a constant DC output resulting in the meter indicating the 100 kHz marker, meaning that the adjusted and phase-locked frequency results in an integral multiple of 100 kHz but not of 1 MHz.

The input of the 100 kHz channel contains a mixture of all the difference frequencies between the coarse frequency oscillator frequency and the neighbouring 100 kHz spectrum lines. After being amplified by T 1501 the signal is applied through the matching stage T 1502, and a low-pass filter having a cut-off frequency of 55 kHz and poles at 100 and 150 kHz, is amplified once again (T 1503, T 1504) and then applied to the pulse shaper stage T 1505 of a counting discriminator. Whenever transistor T 1506 is blocked, C 1510 can discharge into the zener voltage of GI 1504 via GI 1505 and R 1510. The mean charging current flows through meter J 2302 and is proportional to the switching frequency of T 1506.

At 50 kHz the meter current amounts to 700 µA corresponding to 1.7 times the full scale value if transistor T 1505 fully conducts. At the limit of the lock-in range, the meter current is reduced to approx. 28 µA (7 % of the current at f.s.d.) and thus aids in locating the lock-in range and recognizing the phase-lockel condition during tuning. When the lock-in range is attained, the meter needle swings into the 1 MHz section of the meter scale and , as long as the pull-in range is not exeeded, remains steady despite the coarse frequency oscillator setting being changed.

This phase-locked condition so obvious that a dip in the tuning indicator reading between two lock-in frequency indications can easily distinguished.

If the coarse tuning oscillator frequency lies between two lines of the 100 kHz spectrum, the resulting 50 kHz difference frequencies can cancel each other out. Very careful adjustment of the coarse tuning oscillator will enable this position to be located at the upper band limit.

This occurence will also be apparent at the input of the 1 MHz channel when locking the frequency of the coarse frequency oscillator to a multiple of 500 kHz. Due to the constancy of the locked frequency, the two 500 kHz signals cancel

each other out and an apparent 1 MHz locked freqeuncy indication results
The input of the 1 MHz channel contains a mixture of all the difference frequencies between the coarse tuning oscillator frequency and the neighbouring 1 MHz spectrum lines. After being amplified by T 1510 the signal is applied through the matching stage T 1509 and a low-pass filter having a cut-off frequency of 550 kHz, is amplified once again by T 1508 and then applied to the limiter compr ising T 1506/T 1507. The square-wave output current of the latter is rectified to an average value representing a constant DC for meter J 2302, this current being widely independent of frequency and input voltage.

### 2.1.16. Saw-Tooth Generator (16)

The circuit (16) supplies voltages required for sweeping the oscillator in the control oscillator section RWO-5, for the horizontal deflection of the display unit and the fly-back pulse during the saw-tooth trailing edge period.
The sweep frequency can be adjusted in steps between 0.1 Hz and 50 Hz.The peak sweep voltage amplitude is ± 3.5 V.
The capacitor selected with switch S 1601/II/b is charged with a constant current through R 1601. To ensure the linearity of the increasing voltage, the capacitor must be only subjected to high-impedance loading. Three series-connected collector stages including T 1601, T 1603, T 1604 and T 1605 constitute a low-impedance, saw-tooth voltage source. The output voltage at the emitter of T 1604 is superimposed by the voltage of the zener diode GI 1602, the cathode of which is connected to the charging resistor R 1601. Since the charging voltage is constantly increased by the amount of the capacitor voltage, the voltage across R 1601 and thus the charging current remains constant (bootstrap-circuit).
The capacitor voltage also represents the collector voltage of T 1606. When the positive maximum value is attained, T 1606 conducts and discharges the capacitor down to its maximum negative value. Direct use of the saw-tooth voltage is made to control the switching. During voltage increase, transistors T 1611 and T 1608 are initially blocked until a value is attained (+ 3.5 V) at which T 1611 conducts. The current through T 1610 is reduced by the common emitter resistance and as a result T 1609 is blocked. Due to the absence of the T 1609 collector current, the base voltages of T 1607 and

T 1610 fall to a negative value determined by the voltage divider comprising R 1624/R 1625 and P 1603. The negative voltage step causes T 1606 and T 1607 to conduct simultaneously, thus initiating the discharge of the capacitor. The discharge current is determined by R 1617. The capacitor voltage falls to a value (- 3.5 V) at which T 1611 is blocked, resulting in all of the following transistors being switched once again. Due to the amplification offered by the feed-back loop between T 1610 collector and base, switching from charge to discharge occurs spontaneously. The positive and negative thresholds, at which switching is to occur, is adjusted with P 1602 and P 1603 respectively. During fly-back, T 1608 is also rendered conducting. The positive pulse at the collector of the latter is amplified also by T 1602 and is available at point 2 of socket Bu 1601 as a low-impedance signal for driving the display unit plug-in SGE-10.

The Display Unit SG-1 and its plug-in SGE-10 extend the Level Measuring Set PSM-5 to constitute the Sweep Measuring Set WM-50. In position 1 of switch S 1601, the deflection voltage can be manually adjusted with P 1601 for static measurements. The peak amplitude is the same as for sweep measurements ± 3.5 V.

In position 11, provision is made for introducing an external voltage, also of ± 3.5 V peak amplitude, for deflection purposes at socket Bu 1601, point 5.

When a sweep frequency lower than that selectable is required, switch S 1601 can be switched to position 10 and an additional capacitor connected parallel with C 1611 across socket Bu 1601 at point 4, thus enabling any sweep frequency below 50 Hz to be obtained. The upper limit of the additional capacitance is determined by the leakage current which must not exceed approx. 2 µA. Sweep width adjustment is achieved with switch S 1602. This switch switches the dropping resistors R 1629 to R 1644 across which the sweep current is supplied to the individual circuits. The sweep currents are determined by dropping resistors from the constant, peak saw-tooth amplitude of ± 3.5 V. In positions 3 to 12 of switch S 1602, the interpolation oscillator is modulated by sweep currents of ± 35 µA to ± 35 mA.

In positions 13 to 17 of switch S 1602, the frequency and phase control stage is modulated by sweep currents of ± 35 µA to ± 700 µA.

In positions 18 to 21 for large sweep widths, the sweep currents are applied to the linearizing network. Here the currents range from ± 385 µA to ± 35 mA.

### 2.1.17. 2.7 MHz Crystal Oscillator (17)

This oscillator generates the auxiliary frequency of 2.7 MHz required to convert the output frequency of the interpolation oscillator to between 2.99 and 3.1 MHz. The crystal oscillator is phase-locked to the standard frequency. This local oscillator comprises the common-emitter limiter T 1706/T 1707. The oscillator voltage is created in the 2.7 MHz tuned circuit in the collector lead of T 1706, the amplitude of which is determined by R 1716 and the emitter current of T 1706/T 1707. Feed-back is achieved from the winding 3-4 of the transformer Ü 1702 via the series configuration of capacitance diode GI 1703 with the resonant crystal Q 1701. This series circuit together with R 1718 presents a resistive divider for the oscillator frequency, which causes only a small reduction of the feed-back voltage for the desired main resonant frequency. For the neighbouring resonant frequencies of 2.76 and 2.79 MHz, however, the dividing ratio is so unfavourable that the amplitude condition for initial oscillation is no longer given. To ensure initial oscillation for transistor combinations having extreme characteristics, the operating point T 1706 is stabilized by a negative DC feed-back through R 1713. Otherwise it could happen that T 1707 takes over the full current on conducting thus resulting in loss of initial oscillation. The 2.7 MHz signal is decoupled via the collector of T 1707.

With the aid of the capacitance diode GI 1703, the oscillator frequency can be influenced by the control voltage. A coincidence circuit comprising transistors T 1702/T 1703 supplies this control voltage by comparing the phase of a 100 kHz signal derived from the standard frequency with that of the oscillator output signal. T 1704 acting as a blocking oscillator generates an output pulse of approx. 150 ns across coil 5-6 of the transformer Ü 1701, this pulse being phase-locked to the 100 kHz standard frequency signal. The transistors T 1702/T 1703 conduct during the pulse duration. Current distribution through the transistors is determined by the phase condition of the 2.7 MHz signal. The output is obtained directly at Ü 1702 via the buffer stage T 1705. If, for instance, the base of T 1703 remains negative during conduction of the coincidence stage, T 1702 will always assume the current, i.e. output current

pulses result at the collector of T 1702 which are integrated by the following low-pass circuit comprising C 1702, R 1705, R 1710 and C 1706 and generate a negative control voltage of approx. -12.5 V.

In the other case, when positive voltage is present at the base of T 1703 during conduction, no voltage will result. Between these two limits, any voltage value is possible depending on the phase condition. In the absence of synchronization, an AC voltage will result whose frequency corresponds to the difference between the oscillator frequency and the desired frequency.

The blocking oscillator is driven via the buffer stage T 1701. The square wave output of the latter is differentiated by C 1704 and R 1704 to generate positive spikes for triggering the blocking oscillator.

Blocking oscillator conduction is determined merely by the inductance offered by winding 3,4 of transformer Ü 1701 and the value of the supply voltage.

### 2.1.18. Interpolation Oscillator (18)

This oscillator serves to effect fine adjustment of the control frequency. Strict requirements are thus made on its stability. With the aid of a reactance circuit acting in parallel with the oscillator tank circuit, sweep deviations up to 17.5 kHz can be produced with the aid of the output signal of the saw-tooth generator.

The transistors T 1805 and T 1806 form an emitter-coupled differential amplifier. The output current of T 1806 as determined by R 1816 and base voltage bias is applied to the resonant circuit mounted on printed circuit board 241-C. Feed-back is achieved via the base of T 1805. The oscillator amplitude is governed by resistor R 1817 and it is this resistor that determines the load impedance of T 1806. The output from the common-base stage T 1804 has an exceptionally low retro-action.

The complete circuit, including the reactance circuit comprising T 1807/T 1808, is operated with a stabilized, filtered DC voltage, since otherwise interference voltages superimposed on the supply voltage would cause spurious modulation of the reactance circuit.

The reactance circuit comprising transistors T 1807/T 1808 forms an inductance in parallel with the resonant-circuit inductance L 1803; the former reducing the latter by approx. 3 %.

The inductance is proportional to the values of C 1814 and P 1801, R 1818 and inversely proportional to the current flowing through T 1807/T 1808. This current is modulated to effect frequency modulation. The saw-tooth current modulated in the emitter of T 1809 results in a proportional control voltage across R 1826, which is present at the base of T 1808 and due to the high emitter resistance of this transistor, generates a proportional current variation.

The deviation of ± 17.5 kHz, which should result at a sow-tooth current of ± 3.5 mA, is adjusted with potentiometer P 1801. The selected deviation must be independent of the selected oscillator frequency. In the absence of a correction circuit, however, the deviation would vary according to the oscillator frequency range 2.9 to 4 MHz in the ratio 4/2.9. For this reason the inductance L 1802 is placed in parallel to capacitor C 1814 thus resulting in an increase of circuit capacitance with increasing frequency, thus opposing the effect of the reactance circuit. In this manner a near constant deviation is achieved over the whole frequency range.

The oscillator output signal is decoupled across R 1815 and controls, via T 1803, the limiter amplifier comprising T 1801/T 1802. The output current of T 1801 feeds the tuning indication (19) and the 10 : 1 frequency divider (22) .

The presence of a signal at socket Bu 1801 is determined by the condition of diode Gl 1801. When a voltage of + 6.3 V is available at point 2, the diode conducts and the output signal is short-circuited by C 1801. This is desired when the counting discriminator II (10) is to be driven with the interpolation oscillator frequency converted in the range 2.99 to 3.1 MHz (interpolation range 110 kHz).

### 2.1.19. Tuning Indication Circuit (19)

This circuit and the subsequent discriminator have the task of indicating the exact frequency tuning of the interpolation oscillator in increments of 10 kHz at meter J 2301.

To do this, the circuit receives a 10 kHz signal from the 10 : 1 frequency divider (12b) which is derived from the standard frequency oscillator. This signal is converted into narrow pulses, having a repetition frequency of 10 kHz, by transistors T 1902 and T 1906. T 1902 operates here as a buffer stage and generates by means of differentiation (C 1904, R 1912) control pulses for the blocking oscillator T 1906. The pulse

During the duration of the pulse the blocking oscillator output causes the differential amplifier comprising transistors T 1904 and T 1905 to conduct. The coincidence of this conduction period with the input signal at T 1904, which is derived from the interpolation oscillator, controls the magnitude of the output pulse from T 1905. The circuit thus operates, in principle, as a phase comparator.

The collector current pulses from T 1905 are integrated by the 5 kHz low-pass filter resulting in the difference frequencies of the interpolation frequency being available at the low-pass filter output for the following 10 kHz increments. An amplifier following the low-pass filter supplies the subsequent discriminator with the required control voltage.

### 2.1.20. Frequency Converter (20), Buffer and Switching Stage (21)

The purpose of the frequency converter is to convert the interpolation frequency 290 to 400 kHz (divided 10 : 1 by the frequency divider (22)) into the frequency range 2.99 to 3.1 MHz.

The switching stage has the task of supplying the counting discriminator II with either the 2.9 to 4 MHz signal supplied directly from the interpolation oscillator or the converted signal.

A low-pass filter mounted on circuit board 241-D at the signal output of the mixer allows only the fundamental of the 290 to 400 kHz square-wave input signal to pass. The mixer itself consists of the two transistors T 2001 and T 2002 and operates as a mixer in push-pull configuration to suppress the carrier. An ideal push-pull mixer chops the marker signal voltage as dictated by the carrier frequency and thus acts as a switch. This is achieved here by a differential amplifier, which is turned on and off at intervals dictated by the carrier frequency. The common-emitter impedance of the amplifier consists of the parallel arrangement of the high-impedance of the carrier current source and resistor R 2008. The task of this resistor is to ensure a rapid discharge of the stored charge of the carrier transistor during blocked conditions. The large negative feedback resistors in the emitter leads result in a high linearity and balance.

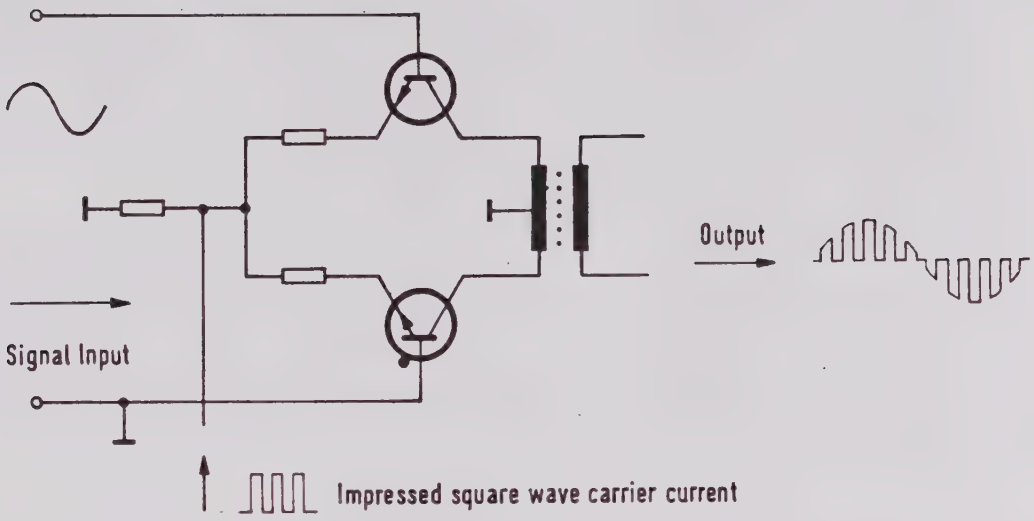



Fig. 3

The sum frequencies 2.99 to 3.1 MHz occuring following the mixer are selected by a sharp band-pass filter arrangement, which possesses a particularly high attenuation for the carrier frequency of 2.7 MHz and the difference frequencies of 2.3 to 2.41 MHz.

Compared with simple diode modulators operating in push-pull, the above mentioned circuit has the advantage that the carrier and marker signals can be applied unbalanced and also that the attenuation caused by the mixer can be compensated by simultaneous amplification.

Following the band-pass filter at the mixer output, an amplifier is provided which drives the emitter-coupled frequency limiter stage comprising T 2104/T 2103.

When a voltage of + 6.3 V is present between point 2 of circuit board 241-J and ground, diodes GI 2106 and GI 2101 conduct whilst GI 2102 and GI 2101 are blocked. This condition of the switching stage (gate circuit) is indicated by pilot lamp 2101.

The output signal from T 2103 is short-circuited by GI 2101 and separated from resistor R 2115 by GI 2102 and GI 2103. Since the voltage of + 6.3 V (measured against ground) at point 2 of the interpolation oscillator (circuit board 241-A) is simultaneously turned-off, the output of the interpolation oscillator is now applied to diodes GI 2105 and GI 2104, which are no longer blocked, to the resistor R 2115 and is thus also applied to the input of counting discriminator II.

### 2.1.21 10 : 1 Frequency Divider (22)

The circuit divides the frequency of the interpolation oscillator and supplies the signal to the frequency converter (20) which then adds 2.7 MHz. The output frequency of 2.99 to 3.1 MHz following the frequency converter is thus varied by only 100 kHz when the frequency of the interpolation oscillator is varied by 1 MHz. This enables an expansion of the interpolation oscillator scale by a factor of 10 to be achieved.

The low-pass filter located at the frequency converter output has the task of selecting the fundamental. This is assisted by arranging for the divider output signal to have a duty cycle of 1 : 1 thus suppressing the second harmonic.
It is for this reason that the frequency dividers (22) and (12) are each of a different design.
Divider (22) comprises a 5 : 1 divider working into a 2 : 1 divider thus enabling the desired duty cycle of 1 : 1 to be achieved. The table shown in circuit diagram (22) illustrates the relative changes in the operating cycle of the transistors and diodes.

### 2.1.22. Discriminator (23)

This discriminator converts the output of the tuning meter circuit (19) into a direct current proportional to this frequency for meter J 2301. The circuit arrangement of the tuning indicator-discriminator-meter circuit enables the interpolation oscillator to be easily compared with a 10 kHz spectrum line of the standard frequency at an accuracy of better than 20 Hz.
An almost sinosoidal control voltage with a peak-to-peak amplitude of 2 V is applied to the discriminator input causing the alternative conduction of transistors T 2301 and T 2302. This results in a square-wave voltage of approx. 11 V at C 2304, which charges and discharges the capacitor as dictated by the input frequency. The charging current surges are rectified and generate a DC voltage across C 2305. A meter current proportional to this DC voltage flows through the branch comprising R 2304 and meter J 2301 which are both in parallel with C 2305. The discriminator characteristic is non-linear since the DC across C 2305 increases with increasing frequency and thus the amplitude swing, which serves to charge C 2304, is reduced. The slope of the characteristic is thus reduced with increasing frequency.

In the sweep mode the false impression must not be given that the centre frequency of the interpolation oscillator can be exactly adjusted. To enable this meter 2301 receives an additional current which generates a full-scale deflection during sweep operation. In all positions of the sweep deviation switch S 1602 the + 6.3 V voltage at point 5 on circuit board 241-AJ is switched off thus rendering GI 2306 non-conducting. This results in a voltage of - 9 V across GI 2306 and generates sufficient current through R 2311 for a full-scale deflection.
Under normal operating conditions approx. + 0.65 V is present across GI 2306. The effect of this voltage upon the meter reading is compensated for by resistor R 2309. Gi 2305 limits the current through J 2301 to approx twice or three-times f.s.d. Circuit board 241-AJ also includes a relay which is activated in the positions 18, 19, 20 and 21 of the mode selector switch 1602, thus enabling an additional current to be applied to meter J 2302 for f.s.d. This is to avoid an apparent phase-lock indication of the coarse tuning oscillator at sweep deviations in excess of ± 1.75 MHz.

The emitter stage comprising transistor ASY 26 is accomodated on circuit board 241-C for reasons of space and serves to filter an auxiliary voltage for the interpolation oscillator. Interference voltages superimposed on this voltage would lead to an undesirable frequency modulation of the oscillator.

### 2.1.23. Power Supply (24)

The power supply has the following tasks:

To supply the instrument with 5 different DC voltages each independent of mains voltage fluctuations.

To provide both AC line and battery operation

This unit comprises the following circuits:

1) Voltage supply for two-point regulator
2) Two-point regulator
3) Chopper
4) Rectifier and filter network following 3) above

This power supply features high efficiency and compact dimensions.

1) Voltage Supply for Two-Point Regulator

In the AC line mode, the mains AC is applied via the power transformer Ü 2401 (suitable adjusted) to the bridge rectifier circuit comprising diodes GI 2403 to GI 2406 The chokes L 2402 and L 2403 reject high-frequency interference superimposed on the AC line voltage.

In the battery operating mode, the direct voltage is applied through socket Bu 2401, choke L 2401 and the protective diode GI 2401 to the parallel arrangement of the charging capacitors C 2401/C 2402. Whereby battery ground polarity is arbitrary. Choke L 2401 protects diode GI 2401 from excessive transient currents, the latter ensuring that an incorrect battery polarity connection will cause no damage. Should both battery and AC line supply voltage be switched on simultaneously, loading is effected only on the DC source when the rectified AC (voltage across the charging capacitor) falls to a value below that of the battery voltage.

2) Two-Point Regulator

The purpose of this circuit is to maintain the mean value of the voltage across capacito C 2404 to approx. 19 V and to limit the charging current for this capacitor to a value dictated by P 2401 of 6.5 A.

Transistor T 2401 then assumes the function of an ON/OFF switch; the diode GI 2407 receiving the current during the blocking period of this transistor.

The most important part of the circuit is the Schmitt-trigger comprising transistors T 2403, T 2405 and T 2406 which is shown in the following diagram:

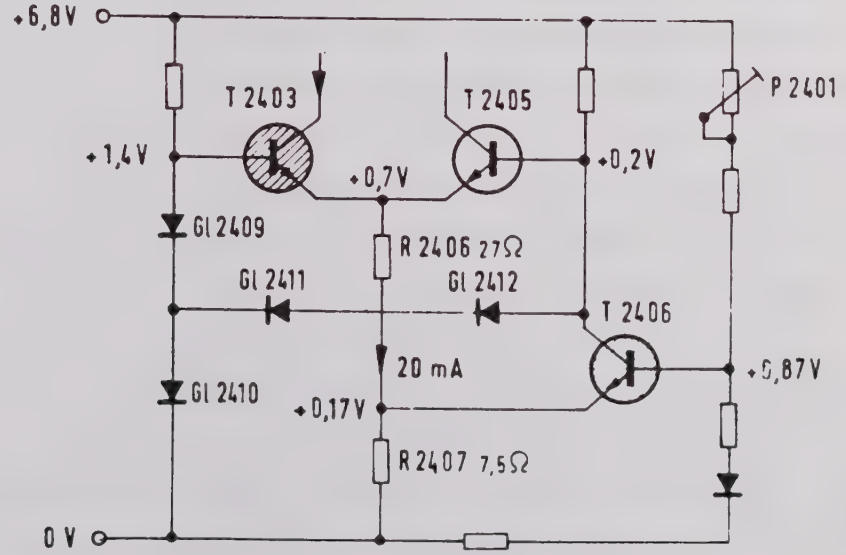



Fig. 4

T 2403 is conducting (indicated by the shading). The voltage at the base of T 2406 must fall below + 0.87 V to actuate the trigger stage.

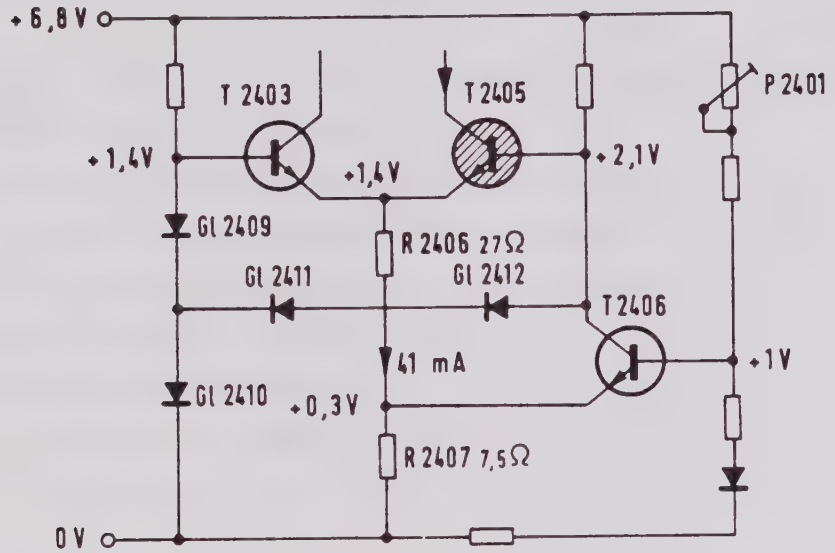



Fig. 5

T 2403 is now blocked. The triggering stage switches as soon as a voltage of + 1 V is exceeded at the base of T 2406.

All potential values given in the circuit diagram are referenced to 0 V (point 3 of printed circuit board 241-N).

All operative potentials of the circuit are determined by the forward voltage of diodes Gl 2409 to Gl 2412 together with the emitter-base voltages of transistors T 2403 and T 2405 and the voltage drop across R 2406. When T 2403 is conducting a voltage of + 1.4 V (two silicon threshold voltages in series) is formed at the base and a voltage of + 0.7 V at the emitter. When T 2403 is blocked (T 2405 conducting) a voltage of + 1.4 V can be measured between the common-emitter and ground. The currents are therefore determined by the resistors R 2406 and R 2407 together with the threshold ratio of the trigger.

If T 2405 conducts, because the base voltage of T 2046 is less than + 0.87 V, T 2402 will receive a base current of 41 mA, which is sufficient to cause itself and T 2401 to fully conduct. C 2403 is then charged via Gl 2402 to 0.3 V. This charge is then available for the discharge of the charge carrier via R 2404 on blocking T 2401 if

T 2402 is blocked. The base voltage of T 2406 must exceed + 1 V if T 2401 is to be blocked. T 2403 then conducts followed by T 2404 which causes, practically speaking a short circuit between points 4 and 6 of the printed circuit board 241-N. However T 2402 and T 2401 will be blocked because of this.

The base voltage of T 2406 is governed by 2 different magnitudes:

Firstly the voltage drop across R 2410 and thus the charge current of capacitor C 2404 and secondly by the output signal of T 2407. If one does not consider this output signal, because eg. T 2407 is blocked, then the charge current of C 2404 will increase, after T 2401 conducts, until the voltage drop across R 2410 and the auxiliary current through P 2401 are sufficient to overcome the upper trigger threshold. T 2401 will then be blocked until the lower trigger threshold is overcome due to the reduction of the charge current. The charge current thus varies continuously to and fro between two values, which are, when T 2407 is blocked, only dependent of the position of control P 2401.

T 2407 is blocked during short-circuit of C 2404. In this case P 2401 is adjusted so that the short circuit current flowing amounts to 6.5 A. Since the trigger thresholds determine the maximum values of the current through R 2412, the threshold ratio can be easily found by measuring the AC voltage across R 2427...2430, the peak-to-peak valu being identical to the delta voltage displayed at the oscilloscope.

The output voltage of T 2407 will become effective if the DC voltage across C 2404 deviates from an adjustable nominal value. One should really observe the actual value across C 2404. It is, however, advantageous to measure the real value before L 2405 at points 2 and 5 of the printed circuit board 241-N, since the phase shift of L 2405/ C 2404 is avoided and the control stability is easier to achieve. It is, of course, desi- Since only the DC component is to be kept constant and a constant load may be assumed, this method is permissible. The voltage taken from points 5 and 2 is divided (R 2418, R 2420, R 2419, R 2402, R 2425), averaged over approx. 2 ms (C 2406) and referenced, via T 2408 with the zener voltage at Gi 2414. The output signal of T 2408 is amplified by T 2407 and has an effect on the voltage at the base of T 2406. The output voltage of the two-point regulator can be adjusted with P 2402.

The two-point regulator switches at a frequency of approx. 1 kHz to 35 kHz according to the input voltage. The on and off switching moments could be synchronized by an interference voltage or feed-back from the following choppers. Ripple voltages at 100 Hz would appear during synchronization at the power supply output during AC

operation. To avoid this the choke L 2406 and capacitor C 2407 have been provided in addition to the wiring and screening measures.

3) Chopper

The chopper has the task of forming the various operating voltages for the unit from the output voltage of the two-point action control. The chopper generates square-wave voltages at the output of transformer Ü 2402 at a frequency of 26 to 30 kHz. In contrast with the usual circuitry, which utilize the saturation of the chopper transformer, the chopper transistors are clearly switched by a control current in the base circuit in order to achieve minimum loss.

In the description of the circuit, it is assumed that T 2409 is conducting and T 2410 is blocked. The base current of T 2409 is constant at this moment. The voltage for this is supplied by the feed-back winding 5-6. When T 2409 commences conducting, the end of winding 7 is positive in respect to the centre-tap 8. The voltage drop on the collector-emitter path is practically zero and the constant battery voltage of approx. 19 V is available across winding 7-8. A constant voltage is now also induced into the feed-back winding 5-6 which, corresponding to the turns ratio, will amount to approx. 9 V. The constant base current flows from the positive end 5 of winding 5-6 through resistor R 2422, GI 2416, the emitter-base path of T 2409, R 2421 and returns back to winding 5-6. This base current is so large that transistor T 2409 is saturated even at maximum collector current and minimum current amplification.

A further oppositely orientated current now flows from the positive end 3 of the second feed-back winding 3-4 through choke L 2407, GI 2417, base-emitter path of T 2409 and GI 2419 and returns to winding 3-4. This current commences at a very low level and does not allow the base current of T 2409 to be materially less than the current through R 2421. The opposing current increases, however, with time and thereby causing a corresponding reduction of the base current of T 2409.

The switching cycle is actuated by reversal of the voltage at the windings, if the base current sinks to below the minimum value necessary to maintain the collector current. This can, however, occur only when the charge carriers of the base-emitter path are removed, which is also achieved with current via L 2407.

The base current is therefore firstly zero and increases afterwards in an opposite direction until the charge carriers are cancelled out.

The following voltage reversal at the windings causes the complete blocking of T 2409 and allows T 2410 to conduct. The cycle is now repeated for T 2410.
Without resistor R 2423 the chopper would not commence operation on applying the voltages, because both transistors would be firstly blocked. Both transistors are, however, supplied with base current so that the transistor with the greater amplification will be switched by the commencing feed-back. This "start" current complements the transient base current during chopper operation. Resistor R 2426 and capacitor C 2423 serve in the suppression of any interfering resonances caused by the winding capacity and stray inductance of the chopper transformer. A pure square-wave without overshoot is thus obtained and suppresses interference, such as oscillation at another frequency than that determined by L 2407.

4) Rectification and filtering circuitry following the chopper

These circuits do not possess any special features. Because all voltages are tied together, only one voltage can be set to any specific value by means of the output voltage of the two-point regulator. Stringent requirements have been made in regard to a hum and noise-free heater supply for the receiver. The 6.3. V DC heater voltage chosen fulfils these requirements.
The voltage stabilizer T 2501, T 2502, T 2503 (circuit board 241-AX 1) is provided for the individual adjustment of the 2.9 V operating voltage of the gas pressure relays in the receiver portion.

## 2.2. Generator Portion PS-5

Operation of the complete unit:

The Generator portion PS-5 is always a part of a combination. It is either combined with the Oscillator RWO-5 to form the complete Generator PSO-5 or in conjunction with the Oscillator RWO-5 and the Receiver portion PM-5 to from the Level Measuring Set PSM-5.

The generator supplies an r.m.s. output voltage of approx. 50 µV to 1 V. The output impedance is adjustable from 50 to 150 Ω to match different load impedances. The frequency range of the generator covers the band 10 kHz to 36 MHz. A built-in, disconnectable amplitude control ensures that the indicated output voltage remains constant. The calibration of the output voltage is suitable for the various conditions encountered:

Selection can be made between voltage level and power level calibration for the six output impedances provided.

The generator frequency of 10 kHz to 36 MHz is formed as the difference between the RWO-5 control frequency of 69.01 to 105 MHz and the fixed frequency of 69 MHz. The 69 MHz signal frequency is generated within the generator portion and is phase-locked to the 1 MHz standard signal of the RWO-5. The control signal from the RWO-5 is fed via a limiter to the frequency converter in the PS-5 as the "carrier frequency".

The generator frequency characteristics are therefore exclusively determined by the Oscillator portion RWO-5.

The difference frequency ($f_{carrier} - f_{signal}$) at the output of the frequency converter is fed through a low-pass filter, to suppress the sum frequency and amplified to the required amplitude. The final amplifier possesses an output impedance of 50 Ω and works into an output attenuator with Z = 50 Ω. The various output impedances are formed by additional series resistors subsequent to the attenuator.

The circuitry for the output voltage indication operates as a mean value rectifier and monitors the original voltage preceding the output impedance network of the final amplifier. The indication is only valid during $Z_{out} = Z_L$ conditions.

The amplitude control forms, together with the indicator circuitry, two control stages. One control stage is needed to obtain the mean value rectification and the second serves to stabilize the indicated output amplitude. In this case the amplitude modulator serves as regulating element. This control circuit is also used to adjust the output voltage with the aid of a ten-turn helical potentiometer.

The output socket II with $Z_{out}$ = 75 Ω is independent of the divider output and supplies the voltage available previous to the divider, thus providing a greater out put voltage level for the operation of counters and similar units in addition to the attenuated output voltage.

## 2.2.1. 69 MHz Oscillator (1)

The oscillator operates as a capacitive three-point circuit. The oscillator coil consists of a single coil in the form of a metal bracket. Since the oscillator amplitude is solely determined by the emitter current operating point of the transistor, this amplitude can be adjusted with the aid of P 101. The frequency of the oscillator is held always at a constant 69 MHz by varicaps GI 101 and GI 102, which are supplied with a control voltage from the phase control (2). The buffer stages T 102 and T 103 serve to isolate the oscillator from the subsequent amplitude modulator (3), thus avoiding that a simultaneous frequency modulation can occur by interaction on the oscillator during amplitude modulation.

## 2.2.2. Phase Control (2)

This control compares the frequency of the 69 MHz oscillator to the 1 MHz standard frequency of the RWO-5 and generates the required control current for the synchronization of the 69 MHz oscillator with the control frequency.

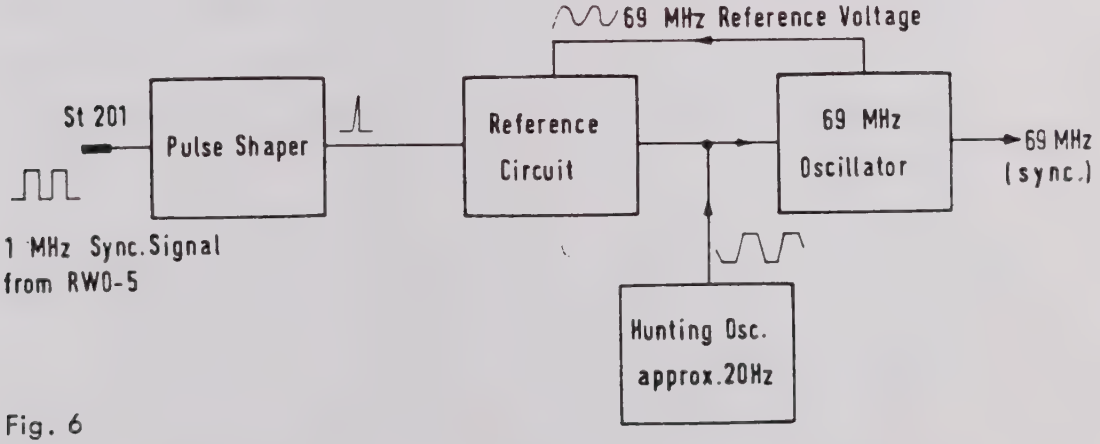



Fig. 6

The pulse shaper stage T 201, T 202 forms very rarrow spikes from the 1 MHz square wave signal, whose phase position to the 69 MHz signal effects the sign and amount of a control voltage.

This control voltage controls the frequency of the 69 MHz oscillator with the aid of the two varicaps diodes so that the phase position is held constant and thus synchronized. Synchronization will not occur if the 69 MHz frequency is not within the "hold range" of the phase control circuit instrument.

The hunting oscillator is, however, operative and sweeps the 69 MHz oscillator. The frequency of the 69 MHz oscillator will pass through the hold range and will thus be synchronized. The hold range has, in this manner, been increased to the value of the hunting oscillator sweep range. The hunting oscillator is so designed that oscillation ceases on loading. This is the case when synchronization is obtained because the feed point of the oscillator is made low-impedance by the effect of the control.

Pulse shcper:

T 201 and T 202 are blocked in their quiescent state. The negative input signal is differentiated by C 201 and switches T 201. The output signal of T 201 is differentiated by C 203/R 204 and then switches T 202, whose output signal, a steep negative pulse, is differentiated by the varicap GI 202 and winding 1-2 of transformer Ü 201. A pulse with a rise time of approx. 3 ns, a width of 15 ns and a peak voltage of 7 V is formed.

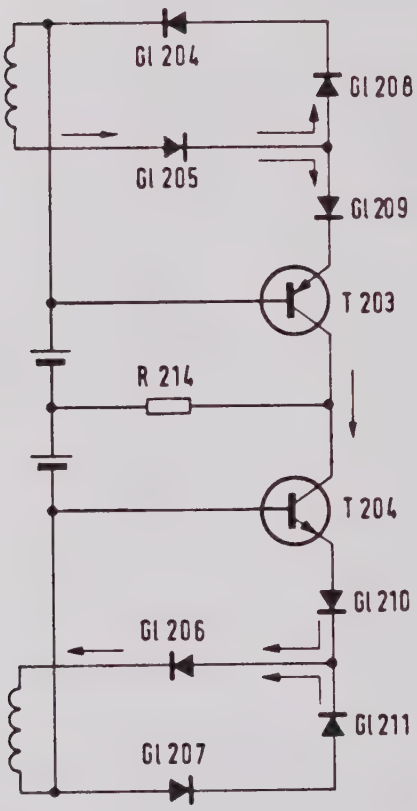
Comparison circuit:

The comparison circuit receives the 69 MHz signal via T 206 and T 205 (approx. 0.5 V at the emitter of T 205) and the 1 MHz pulse via the secondary windings of Ü 201.

T 203 and T 204 will be blocked if these two signals are not present, so that the potential adjusted at P 201 is available at the connection point of the two collectors. P 201 is normally adjusted so that the voltage between TP 202 and TP 203 is approx. zero. This condition is also maintained if only the 69 MHz signal is fed to the circuit. The transistors T 203 and T 204 are also blocked during the pauses between the 1 MHz pulses.

A current will flow via Gl 205 (or Gl 206) on receiving a pulse, which is branched off at the cathode (or anode).

The value flowing via Gl 208/Gl 209 or Gl 210/Gl 211 is determined by the momentary phase position of the pulse to the 69 MHz signal. The following illustration, containing only the relative information, shows the principle when the 69 MHz signal is assumed to be absent.




In a fully balanced condition half of the current flowing via Gl 205 is passed through Gl 209, T 203, T 204 and Gl 210. Thus maintaining the common collector potential of T 203 and T 204. If, however, the current via Gl 209 and through Gl 210 is different, the current difference would flow via R 214 and will shift the collector voltage of one of the transistors to saturation. This could be caused for instance, by a small unbalance of the circuit.

Fig. 7

On feeding the 69 MHz signal via T 206/T 205 a current difference is generated as a measure of the phase difference. Fig. 8 illustrates three different conditions:

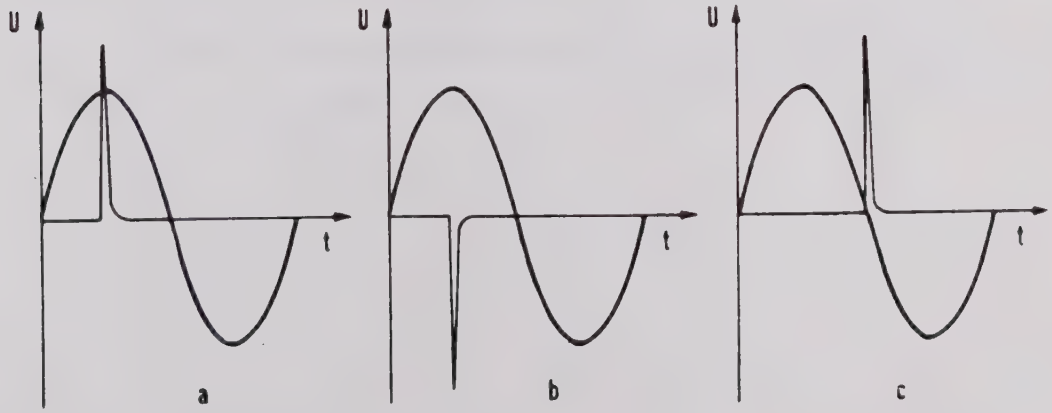



Fig. 8

Illustration a: The pulse coincides with the identical phase maximum of the 69 MHz signal, therefore doubling the current through Gl 209 until Gl 208 is blocked. At this moment the phase position at Gl 210 is as in illustration b.
The current in Gl 201 is doubled whereas the current in Gl 210 is reduced.
The collector potential is shifted in a positive direction and is limited by the saturation. If the opposite phase position is present the signs are exchanged and the collector potential shifted towards minus.

Illustration c: In the phase position shown in c the average current via Gl 209 and GL 210 and thus the collector potential of T 203 and T 204 are not altered. Between the phase positions illustrated in Fig. a to c, there are, naturally, all the intermediate positions. A control voltage dependent on the phase position is thus achieved. As long as the phase position is in a state of transition, a square wave voltage will be developed, whose frequency is dependent on the frequency difference between the 69 MHz and the 69 th harmonic of the 1 MHz synchronizing signal. The low-pass filter (R 218, C 210) ensures that the control amplification for frequencies in excess of 10 kHz is small and that the control is held stable. However, a very narrow hold range is obtained because of this, since no control voltage is generated at greater frequency differences. The collector voltage of the hunting oscillator is slowly shifted (20 Hz) back and forth to the saturation limits, thus tuning the 69 MHz oscillator. This means that the 69 MHz oscillator will be locked-in by the control voltage on reaching a frequency within the hold range and the hunting oscillator will then cease operation.
It is imprtant that no spurious alternating voltages are present at the varicaps of the 69 MHz oscillator as these could cause a frequency modulation. The most serious interference would be that originating from the 1 MHz standard. A 1 MHz absorption circuit consisting of C 211 and L 201 ensures, in conjunction with the low-pass filter elements, an effective filtering.
Potentiometer P 201 serves to compensate for circuit unbalance, thus obtaining a hold range balanced is respect to the nominal frequency.

## 2.2.3. Amplitude Modulator (3)

The amplitude modulator consists of a simple diode modulator, the principle of which is illustrated below:

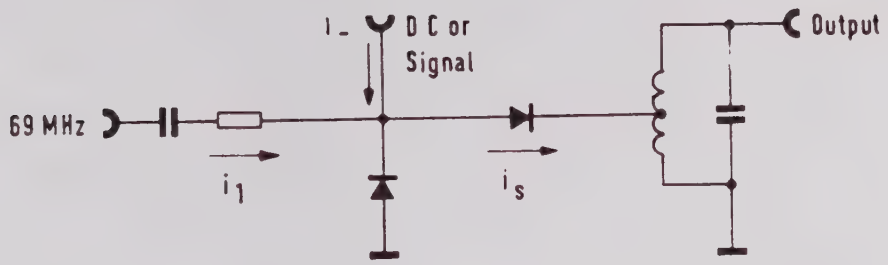
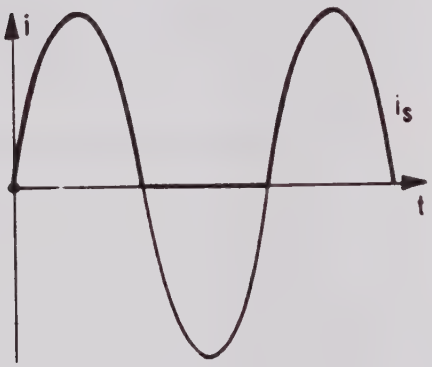



Fig. 9

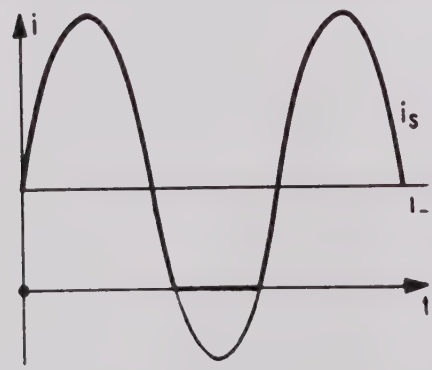
A 69 MHz sine-wave current $i_1$ is supplied to the input. Under no current conditions at the DC input, the trace will have the illustrated form:




The current $i_s$ in the resonant circuit is formed merely from the positive half cycle and its trac is as shown by the accentuated curve.

Fig. 10 a

If a positive DC is fed to the modulator in addition to the current shown in Fig. 10 a, it will be superimposed on to the sine-wave current $i_s$.




The sine-wave $i_s$ in the resonant circuit is indicated by the accentuated curve.

Fig. 10 b

If a negative DC current is injected, then the trace will be as in Fig. 10 c

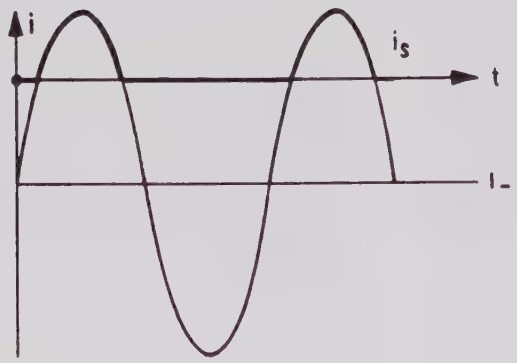



Fig. 10 c

All of the accentuated curves possess a fundamental component of the 69 MHz oscillation, in "b" more and in "c" less than in Fig. 10 a. The output voltage at the resonant circuit is proportional to this fundamental amplitude. This allowing the value of the 69 MHz to determined by the magnitude and polarity of the injected DC. If an LF signal current is fed instead of the DC, this will have the result that the output amplitude will be varied in step with the LF, thus forming the modulation.

## 2.2.4. 69 MHz Amplifier (4)

This amplifier essentially represents a band-pass filter for 69 MHz, which is loosely coupled via a buffer and intermediate amplifier stage. This loose coupling has the effect that with simultaneous RF amplification no dip in the filter curve is made which would be a disadvantage with regard to the modulation side bands. The filter curve is, however, so broad that the modulation side bands are passed unattenuated.

## 2.2.5. Frequency Converter (5)

The task of the converter is to form the required 10 kHz to 36 MHz frequency range of the generator portion from the variable carrier frequency (69,01 MHz to 105 MHz) of the RWO-5 and the fixed 69 MHz signal frequency generated in the PS-5.
Since the converter operates according to the ring modulator principle, the essential mixer products are $f_{carrier} + f_{signal}$ and $f_{carrier} - f_{signal}$. The difference product is used in the PS-5. The sum product and all frequencies in excess of 36 MHz are suppressed in the following low-pass filter (6). The control signal is fed as carrier signal via a limiter circuit (11) to transformer Ü 501 of the converter, where it is balanced, amplified by T 501 and T 502 and passed to transformer Ü 502 of the mixer. The signal frequency is also fed balanced to the mixer. Due to the unavoidable wide tolerances, the diodes have been balanced by series resistors in the forward direction and by parallel resistors in the reverse direction. This allows the demands on the mixer in regard to carrier and signal suppression to be met.

## 2.2.6. 36 MHz Low-pass Filter (6)

This low-pass filter has the task of filtering out the difference product $f_{carrier} - f_{signal}$ from the unwanted mixer products.
The cut-off frequency is at 36 MHz. All frequencies above 36 MHz, especially the sum products will be attenuated by more than 80 dB.

## 2.2.7. Pre-amplifier (7)

The pre-amplifier consists of 2 negative current feedback amplifier stages T 702 and T 704, which are matched to each other and to the in and output by means of buffer stages. An increase of the frequency response is made with C 705 and C 708, which can in turn be reduced by trimmer C 707. This allows the frequency response of the combination pre-amplifier and output amplifier to be adjusted.

## 2.2.8. Output Amplifier (8)

The output amplifier has a complement of complementary transistor stages. All stages are series push-pull stages, ie. the transistors are placed in series with each other across the DC. The output stage comprises two parallelconnectedpush-pull stages and the output impedances are formed by use of defined series resistors which operate as parallel resistors for the individual outputs.

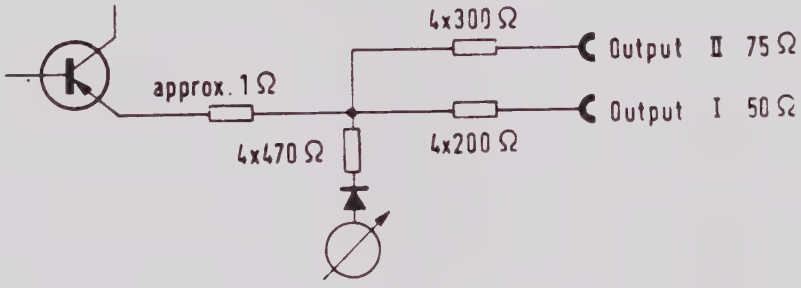



Fig. 11 Equivalent circuit diagram of one of the 4 parallel connected branches of the output stage.

The output impedance for the connection of the indicator circuit is a portion of the series resistance, which is needed for the mean value rectifier. The meter thus accurately indicates the source voltage of the output stage.
L 801 at the output of the driver stage T 801/T 802 serves to compensate for the input capacity of the following stage and to equalize the frequency response at the upper band limit. The resistor parallel to L 801 prevents an out of band response lift, which would otherwise cause an increase in the harmonic distortion at approximately 20 MHz. The DC operating point for the complete output stage is adjusted with P 801 to obtain the lowest possible harmonic distortion.

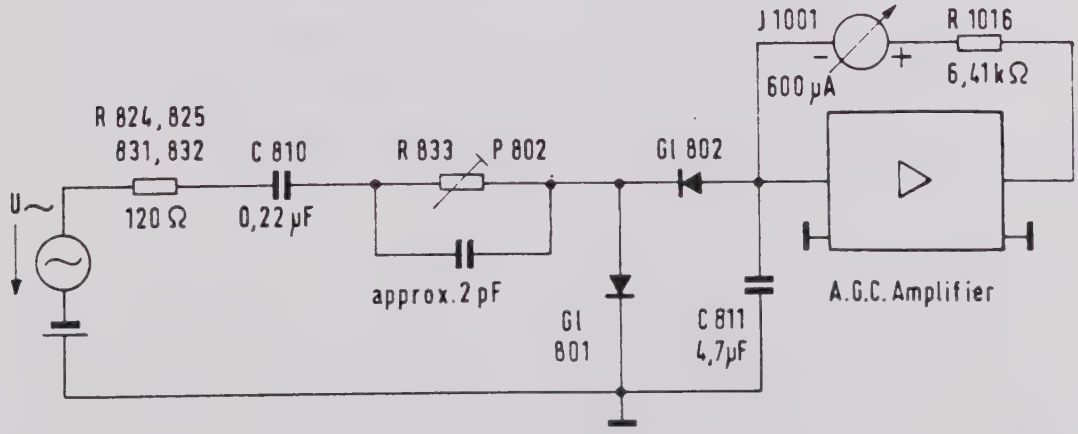



Fig. 12 Indicator circuit

If two conditions are fulfilled, a direct current proportional to the AC voltage U ~ will flow via GI 802 into capacitor C 811. These conditions are:

1) Capacitor C 811 must not accept any inverse voltage charge, which could cause GI 802 to conduct during the whole half wave.

2) The curve of the rectifier must be linearized with a sufficiently large series resistance (R 824 to R 833) in order to obtain the proportionality between current and voltage.

The first condition is fulfilled in that a control amplifier feeds C 811 with an inversed DC of equal magnitude. This compensating current is indicated on meter J 1001 and exactly corresponds to the direct current flowing via GI 802 if the control amplifier requires a negligible current and if the voltage across C 811 can be zeroed. These requirements can be made with a sufficiently high control amplification.
C 810 serves to provide a DC-free output . GI 801 prevents C 810 from being charged and additionally allows the generation of a bias current.
The threshold voltage of the rectifier will have an unfavourable effect if the AC voltage is low. Its influence on the proportionality between the alternating and direct current will then no longer be negligible. For this reason, a bias current is fed from the control amplifier to just overcome the threshold voltage. The forward voltage of the series connected diodes then appears at C 811 in the absence of an AC voltage. The condition 1) above can be condensed as meaning that no voltage variations should take place at C 811 in the presence of an AC voltage.

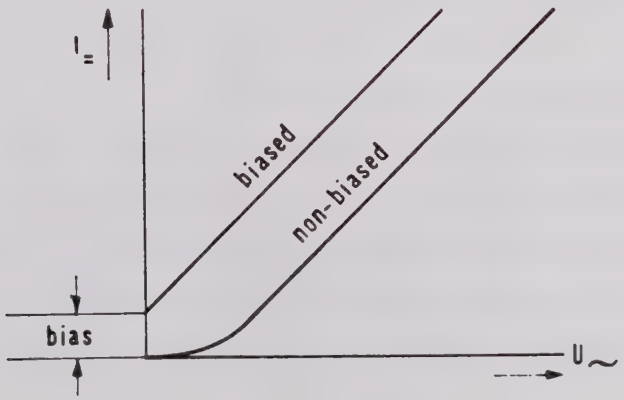



Fig. 13

Control amplifier for the indicator circuit (circuit diagram 10 )

The control amplifier comprises the transistors T 1006 and T 1005. The output voltage is available at the emitter of T 1005. Comparison is made at the input (base-emitter of T 1006) between the voltage at C 811 and a voltage obtained from P 1004. The required bias current can be selected with the aid of P 1004. Since the forward voltage at C 811 is effected by the temperature dependence of the two diodes, it is advisable to provide a comparison voltage with an identical temperature coefficient. This is achieved by the base-emitter diode path of T 1006 and by GI 1005.

## 2.2.9. Attenuator (9)

The attenuator consists of four combinable L pads with the values 20 dB/10 dB/20 dB/ 20 dB or 2 Np/1 Np/2 Np/2 Np at an impedance of Z = 50 Ω. (in circuit diagram left to right). The attenuator pads are selected by attenuator switch S 901 with the aid of reed contacts. Since high demands have be placed on these reed contacts, gold plated contacts have been used. The energizing coils of the reed contacts are partly switched via diodes and due to this it was possible to use a uncomplicated attenuator switch. The resistors R 909 to R 913 are simultaneously switched with output impedance switch S 902 and are used to switch the meter sensitivity in the "power level" position.

## 2.2.10. Amplitude Control (10)

Any variation of the mean value of the AC output voltage will cause a proportional change in the DC voltage at the emitter of T 1005 as well as a variation of the its collector voltage. The amplitude control makes, with the aid of the difference amplifier T 1003/T 1004, a comparison between the collector voltage of T 1005 and the DC voltage selected at P 1002, and equalizes same. If the voltage selected with P 1002 is varied, the output AC voltage will also be altered. The control circuitry needed for this consists of the difference amplifier, amplitude modulator (3) , 69 MHz amplifier (4) , converter (5) , 36 MHz low-pass filter (6) , pre-amplifier (7) and output stage (8) with rectifier circuit.

A rise in the collector current of T 1003 will cause an increase of the AC output voltage, whereas a current decrease will cause a fall-off of same.

With the aid of P 1001 the emitter voltage of T 1001 is adjusted, thus controlling the collector current of T 1002 as well as the voltage drop across the level control P 1002. The voltage drop across P 1002 is adjusted so that at the fully clockwise position of P 1002 the f.s.d. of the meter is accomplished (The emitter voltage of T 1001 is adjusted to 4 V on alignment). The function of P 1002 is still maintained even if the control circuit is broken at socket Bu 1001 because the collector current of T 1003 and thus the AC output voltage are effected by this control. A modulation voltage at socket Bu 1001 would also vary the collector current of T 1003 and thus cause an amplitude modulation of the output voltage. If one ensures, with the aid of diode Gl 1003, that the collector circuit of T 1002 has the same voltage threshold as the input circuit with T 1003, then the collector current of T 1003 will vary proportionally to the position of potentiometer P 1002 or to the modulation voltage at socket Bu 1001. Gl 1004, in the other portion of the difference amplifier (T 1005), is necessary for reasons of balance and to achieve a low temperature coefficient.

The operating point of the amplitude modulator can be varied with potentiometer P 1003. P 1003 must be so adjusted that T 1004 passes current at all times to ensure that the control amplifier is not overloaded within the whole output voltage range.

A second condition of adjustment is the correct position of the control range of P 1002 if the control circuit is non-operational (amplitude modulation).

If the amplitude control stage is inoperative and a resistor is placed in parallel with the link consisting of J 1001, R 1016 and P 1005, the emitter voltage will sink until the current through the meter has been reduced by the value of the addition current flowing through the parallel resistor.

To summarize: The emitter voltage is so reduced that the compensating current originally flowing to C 811 continues to maintain its value. This naturally has no effect on the output level of the output stage. If, however, the amplitude control stage is operative, the output level will continue to increase until the original emitter voltage of T 1005 available before switching of the reference level is reached and thus allowing the original meter current to flow once again.

If the correct parallel resistor has been chosen, the result will be a constant level reading with the corresponding correct output level. Since the level range indication is simultaneously increased by +10 dB (+1 Np), only small corrections of the output level are necessary on switching from voltage to power level calibration. This has a favourable effect on the linearity of the indicator circuitry on switching its sensitivity.

### 2.2.11. Limiter (11)

The two series connected difference amplifier stages operate as a limiter and have the task of limiting the control signal from the RWO-5. This allows the mixer to be fed with a constant carrier signal independent of the amplitude of the control signal.

### 2.2.12. Voltage Filtering (12)

The voltage filtering suppresses high-frequency voltages which are induced into the operating voltage lines of the generator portion.

### 2.2.13. Hunting Oscillator (13)

The hunting oscillator should commence operation as soon as the 69 MHz oscillator is not in its locked condition. The 69 MHz oscillator then supplies a 20 Hz square wave signal which shifts the 69 MHz oscillator into the hold range. The following simplified circuit diagram illustrates the principle of this circuit.

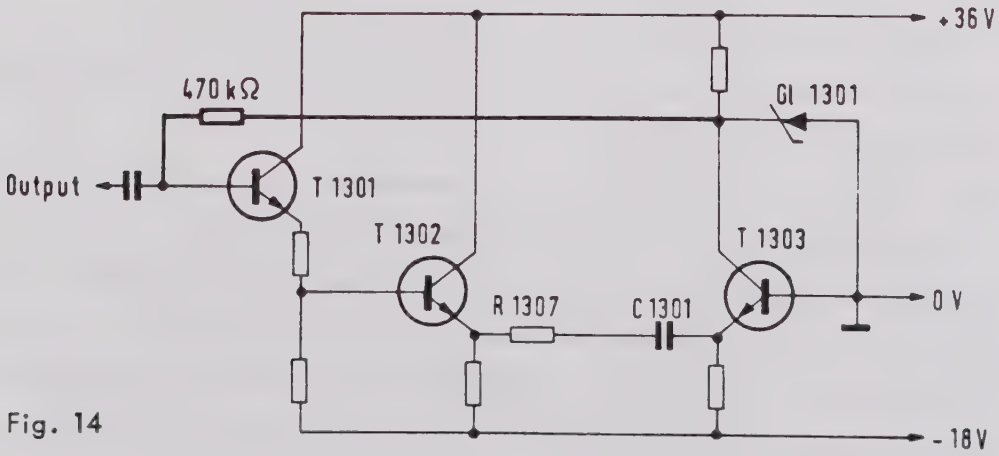



Fig. 14

The line shows the feed-back path connecting the output transistor T 1303 with the input of the circuit. Due to the load resistor at the output, the coupling factor k of the feed-back will be effected by the 470 kΩ series resistor and oscillation will cease as soon as $k \times V \leqq 1$. Due to the high impedance of the feed-back path, this is the case at approximately 70 kΩ.

If the 69 MHz oscillator is not synchronized, the load impedance will amount to approx. 180 kΩ; whereas on synchronization this value will be far lower than 70 kΩ. The hunting oscillator will therefore be switched in and out, since its amplification V is held sufficiently constant by the corresponding circuitry. The oscillator frequency is determined by R 1307 and C 1303. Gl 1301 limits the output amplitude to a defined value.

## 2.3. Receiver Portion PM-5

### Operation of the complete unit

The receiver portion PM-5 is always part of a combination. It is either combined with the Oscillator RWO-5 to form a complete Receiver PMO-5 or in conjunction with the Oscillator RWO-5 and Generator PS-5 to constitute the Level Measuring Set PSM-5. The oscillator Portion supplies the control signal, a synchronizing signal and the stabilized operating voltages. The receiver allows selective measurements to be made in the range from 10 kHz to 36 MHz. The bandwidth is switchable between 500 Hz and 3.5 kHz. The input impedance of the receiver is either high-impedance or any of six different impedances between 50 Ω and 150 Ω. The measured voltage can be indicated as either a linear or logarithmic reading. In addition to this the measurement magnitude can be indicated as a voltage or power level for the available input impedances both with and without terminating resistor. The same meter scale is valid both for the voltage and power level, which has been achieved by correspondingly switching the sensitivity. The dB model also possesses an additional volt calibration.

The wide-band portion of the PM-5 comprises the pre-attenuator for the selection of the sensitivity, buffer and amplifier stages. The first intermediate frequency of 69 MHz is generated in mixer I as the difference of the RWO-5 control frequency (69.01 MHz to 105 MHz) and the receive frequency (10 kHz to 36 MHz). Since the IF is "up-converted", the low-pass filter preceding the mixer ensures a high image rejection. The final intermediate frequency of 30 kHz is obtained after three further frequency conversions. It is at this final IF where the actual selection of the receiver is carried out. The conversion frequencies generated in the RWO-5 are phase locked to another and are synchronized to the crystal spectrum of the RWO-5, thus assuring that the frequency stability of the PM-5 is identical to that of the RWO-5. The signal is then passed via the final amplifier and output-attenuator to the output sockets and to the indicator circuitry. The receiver can be switched to the low-distortion or low-noise mode for the two extreme modes as sweep-receiver or distortion analyzer. Since no attenuation takes place in the most sensitive position of -110 dB (-12 Np), there will be no difference between the low-noise and low distortion measurement. If the sensitivity is to be reduced, then this is made by firstly operating the output-attenuator for low-noise mode or the pre-attenuator in the low-distortion mode.

The receiver possesses output sockets for the 30 kHz IF signal, for a DC output and for an output for headphones.

Voice channels in either the normal or inverted position are placed into their original position by mixing with a built-in frequency conversion oscillator. Double sideband signals are demodulated in the normal manner. The output sockets are floating and fully independent of another. They can be loaded up to short circuit. Sockets are also provided for the accessory Display Unit SGE-10, Scale Expander AZD-1 and Probe TK-8.

### 2.3.1. Input Circuit (1)

The input circuit consists of the terminating resistors, the pre-attenuator and a cathode follower stage comprising the only tube of the Level Measuring Set PSM-5.

The terminating resistors can be switched to the input by the reed contacts of relays 101 to 106. The compensation windings of the adjacent relays are simultaneously switched thus eliminating the effects of the magnetic flux, which could have a disturbing effect on the neighbouring relays, due to the close-spaced assembly. The addition of a low-pass filter has enabled the input capacitance of the unit to be compensated for the impedance values 75 Ω and 150 Ω.

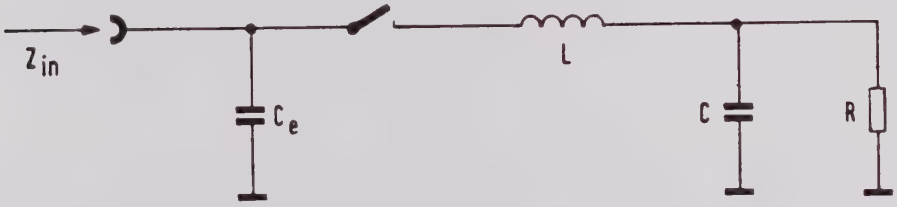



Fig. 15 Terminating resistor

The other Z values are formed by switching a further resistor in parallel.

A 40 dB (4 Np) capacitive divider consisting of C 107 parallel to C 108 and C 110 precedes the cathode follower stage. The input capacity is increased to approximately 30 pF by C 104 parallel to C 106. This value of 30 pF corresponds to the value which would appear if the grid of the tube is directly connected. The capacitive impedance will change at frequencies exceeding 15 MHz and will be also dependent on the setting of the pre-attenuator.

The triode connected valve E 810 F is a low-noise type possessing a mutual conductance

of 50 mA/V. A control circuit comprising transistor T 1901 maintains the valve current at a constant 40 mA.

This control circuit is not part of the input unit but is contained within the printed circuit board "main distributor 243-B". Any low-frequency oscillation of the control stage is neutralized by C 1907 [1] . The combination of R 110 and C 116 in the anode lead compensate the negative real component of the cathode-follower input impedance in the case of capacitive loading. The grid neutralizing resistor can therefore be kept at a low value, so that no additional noise is added to the inherent noise of the circuit. The chosen control circuit allows a high grid leak resistance (R 107) of 10 MΩ, which essentially represents the input impedance of the valve stage at low frequencies. The cathode resistor with a total of 300 Ω is dimensioned as a resistive voltage divider of 0; 10, 20 or 30 dB (0, 1, 2 or 3 Np). The pre-attenuator and the capacitive divider preceding the cathode follower allow the selection of attenuation levels of 0 and 10 to 70 dB (0 and 1 to 7 Np) in steps of 10 dB (1 Np). The coupling to the pre-amplifier is made via two isolating capacitors, which ensure that the relatively slow-switching gas-pressure relays do not cause a momentary short-circuit of the cathode resistor. The taps for 0 dB and 20 dB (0 Np and 2 Np) attenuation are made with series resistors to increase the source impedance to the value of the 10 dB (1 Np) position, thus ensuring that the preamplifier is provided with a constant source impedance. The 30 dB (3 Np) attenuator is calculated for the same source impedance (69 Ω for the dB model or 72 Ω for the Np model).

The frequency response of the various attenuator positions are aligned with trimmer capacitors C 117, C 119 and C 120. Chokes L 103, L 104 and filter resistor R 120 suppress the injection of spurious signals from the RWO-5 via the power supply lines. The calibration signal is fed via relay 112 direct to the grid of the tube. The input isolated by relays 107 and 109.

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[1] Series A to C: C 129

## 2.3.2. Calibration Oscillator 100 kHz (2)

The calibration signal is generated in a low-distortion transistor oscillator stage. The oscillator operates according to the following principle:
A stabilized voltage is momentarilly fed to a high Q resonant circuit on passing through its maximum amplitude and is then allowed to oscillate free during the rest of the period. Transistor T 201 operates as a switch and obtains its control voltage via a feed-back winding of the resonant circuit transformer. The phase, the current flow angle and the magnitude of the commencement pulse are determined by the values of the capacitors and resistors in the base circuit.
The sine-wave calibration signal is tapped off, at a relatively low impedance, from a further winding of the resonant circuit transformer. A voltage divider, possessing a negative temperature coefficient (thermistor R 206), compensates for the temperature coefficient of the zener diode GI 201, which directly controls the amplitude of the oscillation by means of its zener voltage. The calibration signal is available at two output sockets, one at a level of -20 dB and a second at -3 Np. The exact value is adjusted with potentiometer P 201. The oscillator frequency of 100 kHz is aligned at transformer Ü 201. In the production series A to E, the calibration oscillator is fed with its operating voltage only if one of the calibration push-buttons are depressed. Commencing with series F, the calibration oscillator is, in addition, switched on with a slight delay via the base of T 201.

## 2.3.3. Pre-amplifier 10 kHz to 36 MHz (3)

The pre-amplifier consists of an amplifier stage (T 302) preceded by a common-collector stage (T 301) and succeeded by a difference amplifier (T 303, T 304). The emitter resistor of the common-collector stage is at the emitter of T 302 and is thus also effected by the fluctuations of the input voltage. The emitter resistor is thus effectively larger and the input impedance of the pre-amplifier of higher impedance. Due to the alternating switching of the two transistors T 303 and T 304, the difference amplifier has the effect of suppressing the second harmonic. The voltage drop across R 307 is fed back from the collector of T 303 to the emitter of the amplifier stage. This feedback is frequency dependent and allows a compensation of the basic frequency response inductance by means of L 301 - which is dependent on the input unit. The transistor T 304 feeds the 36 MHz low-pass filter at an output impedance of 150 Ω.

The operating point of T 301 is determined by alignment R 314 so that the difference amplifier possesses a balanced current division in the absence of an input signal. Diode GI 301 protects the base-emitter path of T 301 against break-down, should a high AC voltage or peak voltage reach the pre-amplifier from the input. The upper frequency limit is mainly determined by the frequency limit of the current amplification of the transistors.

### 2.3.4. 36 MHz Low-pass Filter (4)

This low-pass filter suppresses all frequencies in excess of the receive frequency band. It is designed for lowest ripple within the pass-band. The three poles ensure a high degree of suppression of the first intermediate frequency of 69 MHz and the image frequency (receive frequency plus 138 MHz).

### 2.3.5. Mixer I and 69 MHz Amplifier (5)

The receive frequency of 10 kHz to 36 MHz is converted in mixer I, with the aid of the RWO-5 control signal (f = 69,01 to 105 MHz), to the first IF of 69 MHz. The IF level is then increased in the subsequent amplifier.
The mixer represents a 150 Ω terminating impedance for the 36 MHz low-pass filter. The two diode pairs switch the input signal ω to the output during a half-cycle of the control frequency Ω. The main mixing products are thus the sum and the difference resulting from the control and receive frequency.

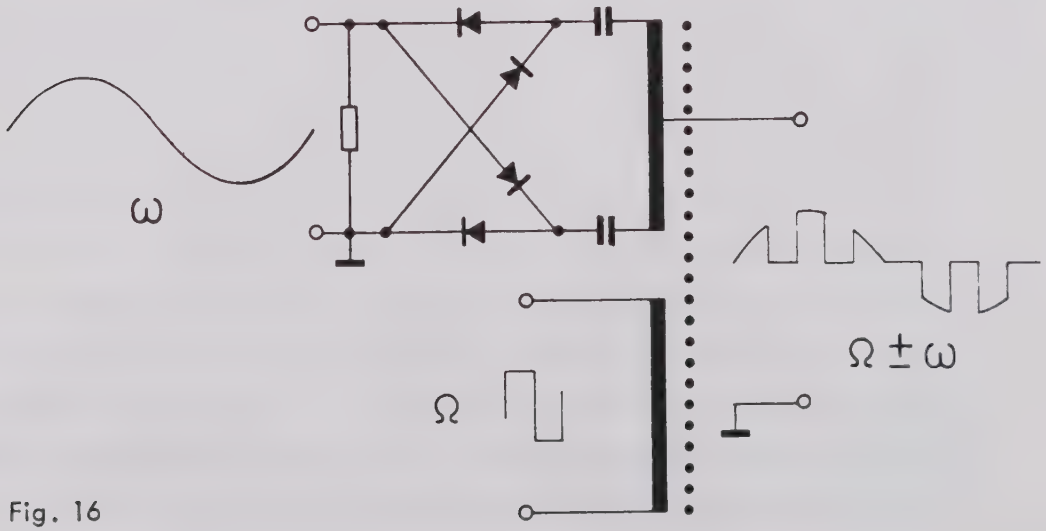


Fig. 16

The difference between both frequencies results in the first intermediate frequency of 69 MHz. Since the carrier level is substantially higher than the signal level, it could reach the output and overload the succeeding stages, if the mixer was in an unbalanced condition. For this reason it is possible to capacitively balance the carrier transformer Ü 501 with the trimmers C 508 and C 510. Differing diode thresholds can be compensated with the aid of a bias current via R 512 and thus allowing the mixer to be resistively balanced. The current is adjusted with the potentiometer P 2001 mounted on the "Distributor 2" printed circuit board.
The potentiometer is also accessable from the rear of the cabinet. R 516 and R 517 represent linearizing resistors for the characteristic curves of the diodes. The 69 MHz amplifier possesses a relatively high input impedance so that the mixer is not loaded. The feed-back resistor R 508 of amplifier stage T 501 is placed across a resonant circuit to ground offering a certain selectivity. The common-base stage consisting of transistor T 501 with its load resistor R 505 operates into the 69 MHz band-pass and suppresses any retroaction of the latter. The operating voltage of the common-base stage is fed at low impedance via transistor T 2001.

### 2.3.6. Limiter 69.01 to 105 MHz (6)

The RWO-5 control signal is converted into a square-wave and limited within the limiter to obtain the lowest possible dependence of the dynamic slope of mixer I on the carrier voltage. The control signal is fed via a low-pass filter, which operates as a image suppression filter, to the limiter stage consisting of T 601 and T 602 [1]. The amplitude of the drive is sufficiently large to fully actuate this stage. The current determined by the common emitter resistor R 605 flows thus solely through one transistor during the first half cycle, whereas in the second half cycle only via the other transistor. The inductance L 601 equalizes the capacitance at the collector of T 602. The second limiter stage comprising transistors T 603 and T 604 generates a sufficiently large square-wave with a high degree of steepness. The mixer diodes GI 501 to GI 504 are thus fully opened via the carrier transformer Ü 501.

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[1] The low-pass filter was replaced by an isolating transformer in series A to C.

A control voltage of $U_{r.m.s.} \approx 0.5$ to a maximum of 2 V can be fed to socket "CONTROL INPUT PM-5" of RWO-5, if it is desired to tune the unit with an external oscillator. The receive frequency will then be at 69 MHz below the control frequency.

### 2.3.7. 69 MHz Band-pass Filter (7)

This band-pass filter consists of three basic $\pi$ links, which are inductive or capacitively coupled to another. Its task is to filter out the first intermediate frequency of 69 MHz from the mixing products of mixer I, whereby the suppression up to 500 MHz must be sufficiently large to ensure a high level of interference rejection. An attenuation peak at 54.12 MHz (C 711) suppresses the image frequencies of the succeeding mixer, which are 2 x 7.44 MHz below the first intermediate frequency. The input of the filter is unbalanced; the output balanced for the driving the transistor mixer II.

### 2.3.8. Mixer II and Buffer Stage (8)

Common-collector stages comprising transistors T 801 and T 802 are provided before mixer II to suppress retroaction from the mixer to the 69 MHz band-pass filter. The base resistors R 801 and R 802 represent the terminating resistors for the band-pass filter. The neutralizing resistors R 804 and R 807 suppress any instability of the two common-collector stages. Mixer II converts, with the aid of a 61.56 MHz carrier oscillator, the first intermediate frequency of 69 MHz to the second intermediate frequency of 7.44 MHz.

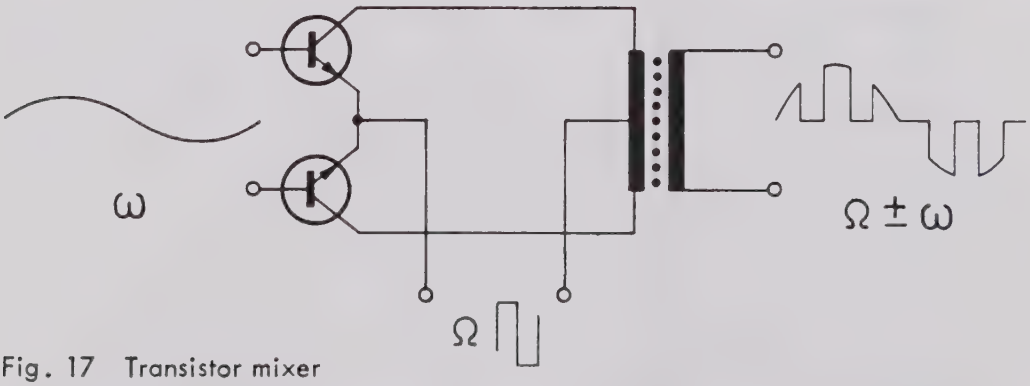



Fig. 17 Transistor mixer

The mixer transistors T 803 and T 804 are switched by the square-wave carrier current. This current is generated in a transistor limiter driven by the 61.56 MHz oscillator. The 69 MHz intermediate frequency only appears at the output of the mixer during the conducting phase of the transistors, which means that the sum and the difference of the first intermediate frequency and carrier frequency are generated. The succeeding band-pass network filters out the difference frequency of 7.44 MHz. The carrier current then flows back through the band-pass transformer and cancels itself out. An intermediate frequency amplifier is not necessary, because the mixer transistors produce a certain degree of amplification during the conducting phase. The task of resistor R 817, at the carrier input of the mixer, is to ground the emitter potential of T 803 and T 804 during the current-free half-cycle. This ensures that the switching point is rapidly reached. Both this and the negative feed-back via the emitter resistors contribute to a low-degree of harmonic distortion.

### 2.3.9. 7.44 MHz Band-pass Filter (10)

The band-pass filter comprises one main and two adjacent links. The main link is divided into two parts. The adjacent links form an attenuation peak at 6.25 MHz, which is the image frequency of the succeeding mixer, appearing at 2 x 600 kHz below the second intermediate frequency. The two band-pass transformers Ü 1101 and Ü 1102 ensure a balanced in and output.

### 2.3.10. Mixer III (11)

This mixer is built up and operates in the same manner as mixer II and converts, with the aid of a carrier frequency of 6.85 MHz, the second intermediate frequency to the third IF of 600 kHz, which is filtered out in the succeeding 600 kHz band-pass filter.

### 2.3.11. 600 kHz Band-pass Filter (11) (12)

This band-pass filter is assembled in the same manner as the 7.44 MHz band-pass filter and its attenuation peak is at the image frequency of the following mixer, which is at 600 kHz - 2 x 30 kHz = 540 kHz.

### 2.3.12. Mixer IV (12)

This mixer is also built up and operates in the same manner as mixer II and converts, together with a carrier frequency of 570 kHz, the third intermediate frequency of 600 kHz to the fourth IF of 30 kHz, which is then fed to the 30 kHz band-pass filter. Diode GI 1203 blocks an emitter-base inverse current during current free condition. of the mixer.

### 2.3.13. 30 kHz Band-pass Filter (14)

The band-pass filter (14) consists of a wide-band and a subsequent additional narrow-band portion. The attenuation curve is relatively flat within the pass band and increases steeply outside same. The attenuation continues to increase in the stop range. In the 500 Hz bandwidth position, the narrow-band filter is switched in behind the wide-band portion. In the 3.5 kHz bandwidth position the narrow-band portion is replaced by a resistor combination, which fully simulates the impedance and inherent loss of the narrow-band filter. In addition to this the temperature dependence of the copper loss in the narrow-band filter are simulated by use of the thermistor R 1403. The attenuation coincidence is made with potentiometer P 1401. The input of the filter is balanced and the output unbalanced with a terminating resistor of 1.2 kΩ.

### 2.3.14. 30 kHz Amplifier I and Post-attenuator (15)

The circuit consists of an amplifier stage containing a transformer output for the logarithmic amplifier and an attenuator output for the linear indication. In addition to this, the amplification for the various power levels is also selected in this circuit. The amplifier consists of a common-collector stage with subsequent common-emitter stage. Since the two transistors T 1501 and 1502 both possess a high degree of current amplification, an extremely high input impedance of the circuit has been obtained, which will not falsify the termination of the 30 kHz band-pass filter. The output impedance of the amplifier will also be high due to the low retroaction of transistor T 1502 and the low-impedance drive to its base. This means that the logarithming diodes can be fed with the impressed current via transformer Ü 1502. In this case the

attenuator output is shorted by relays 1501 and 1502, thus avoiding a voltage-overload of T 1502 at high levels.

In the linear mode, T 1502 also operates into the output-attenuator. In conjunction with matching capacitors, the two transformers Ü 1501 and Ü 1502 form parallel circuits resonant at 30 kHz. The damping resistor across Ü 1501 and thus the sensitivity of the whole unit is controlled with potentiometer P 1501 "CAL lin".

The emitter resistor of T 1502 is varied according to the Z value by switch S 101 in the "POWER LEVEL" position. The feed-back is dimensioned so that the same meter scale can be used. The attenuation scale will additionally be shifted by 10 dB on when switching to the power level mode. The unit is automatically switched to voltage level on depressing the calibrating button. The output-attenuator allows the attenuation of 0 dB, 10 dB to 70 dB (0 Np, 1 Np to 7 Np) and with the aid of the transformer divider stages 10 dB, 20 dB and 40 dB (1 Np, 2 Np and 4 Np). Diodes Gl 1501 to Gl 1506 allow the various attenuator combinations to be switched with a minimum of switch contacts.

### 2.3.15. 30 kHz Amplifiers 2 and 3 (16)

These two amplifiers possess essentially the same circuit as amplifier 1. However since the amplification is greater, it was necessary to place an additional common-collector stage in the circuit in order to avoid a too greater capacitive loading of the input common-collector stage. The current amplification of this transistor serves to increase the input impedance. This is necessary to ensure that the output-attenuator is not loaded in the linear mode. The high output impedance of the output transistor T 1608 is required because the output circuitry is to be fed with impressed current. The neutralizing resistors R 1621 and R 1622 and the common-collector stages T 1604 and T 1607 avoid a negative input impedance of the amplifier. A parallel low Q resonant circuit is to be found between the two amplifiers to short-out all frequencies not adjacent to 30 kHz. The antiparallel diode at the L 1601 tap limits the drive to the final amplifier and ensures that the meter pointer remains at f.s.d. when overdriving.

Transformer Ü 2601 is shorted by relay rel 1604 in the linear mode to ensure that no 30 kHz signal voltage can be induced into the high-impedance input.

## 2.3.16. Output Network (16)

Transistor T 1608 feeds its current into the transformers Ü 1602 to Ü 1605, which have been resonated to 30 kHz by means of parallel capacitors. These transformers allow the various outputs to be floated. The DC voltage is gained by mean-value rectification at diodes GI 1607 and GI 1608. The low-pass filter formed by C 1622 and L 1603 is dimensioned so that an optimum transient response is obtained in conjunction with the non-flattened delay response of the 30 kHz band-pass. This is especially important during swept-frequency measurements on test objects possessing quickly varying attenuation variations. The rise time at a bandwidth of 3.5 kHz amounts to $t_{rise}$ = 0.8 ms and at a bandwidth of 500 Hz $t_{rise}$ = 2 ms. The rectified and filtered current flows via meter J 1901 (600 µA for f.s.d.) and the 10 kΩ measurement resistor R 1619.

The direct voltage of 6 V (= 600 µA x 10 kΩ) corresponding to f.s.d. is available at sockets Bu 1602/1 (DC output "U = ") and Bu 1601 ("SGE-10"). Socket Bu 1601 is used when extending the PSM-5 into the Sweep Measuring Set WM-50 (see WM-50 Manual) and is used to provide the DC signal for the Y-deflection of the Display Unit SG-1/SGE-10.

The meter will indicate the reference line generated in the Display Unit SGE-10, if switch S 1801/5 is in its "REFERENCE LINE" position. During this, the meter is simulated by resistor R 1801 in the DC path of the rectifier circuit so that the measuring value continues to be present at the DC outputs. The voltage corresponding to the level meter reading appears at socket Bu 1603 (AZD-1). The operating voltages for the range expander are also available at this socket. The intermediate frequency of 30 kHz at an output impedance of 600 Ω can be taken from socket Bu 1602/2. Under non-load conditions the level will correspond to the PM-5 meter reading.

The demodulator circuit is used to transpose the amplitude modulated carrier information into the original AF position. Double sideband signals are demodulated in the normal manner by diodes GI 1609 and GI 1610 and are subsequently filtered. Single sideband signals are demodulated with the aid of an additional carrier fed to transformer Ü 1605, which converts the receive signal into the original position.

In the "WIDE BAND" position the bandwidth of the unit corresponds to the frequency range of a voice channel. The carrier frequency used in the single sideband demodulation of the fourth intermediate frequency is either 28 or 32 kHz depending

on whether the sideband is in its normal or inverted position. In the "NARROW BAND" position the sideband signal is converted to approx. 1 kHz by a carrier frequency of 31 kHz or 29 kHz. The output voltage corresponding to f.s.d. of the meter will amount to approx. 500 mV for a converted single sideband signal and approx. 150 mV for a demodulated double sideband signal (m = 30 %).

## 2.3.17. Logarithmic circuit (16)

Silicon diodes exhibit a strictly logarithmic relationship between current and voltage in the low forward voltage range. This effect is used to obtain the desired logarithmic values at diodes GI 1601 and GI 1602. The differential diode resistance and the corresponding voltage drop increase in a logarithmic manner with a linear increase of current.

Relays Rel 1601 to 1604 are energized in the logarithmic mode. The 30 kHz amplifier 15 feeds the current i via the diodes, which are antiparallel-switched in regard to AC voltages. The AC voltage drop u across the diodes is amplified in stages 2 and 3 and is subsequently rectified. The following DC amplifier supplies a bias voltage U to the diodes, which is proportional to the output magnitude. The operating point on the characteristic curve of the diodes is so chosen that the voltage drop across the differential resistor will be U $\sim$ log i .

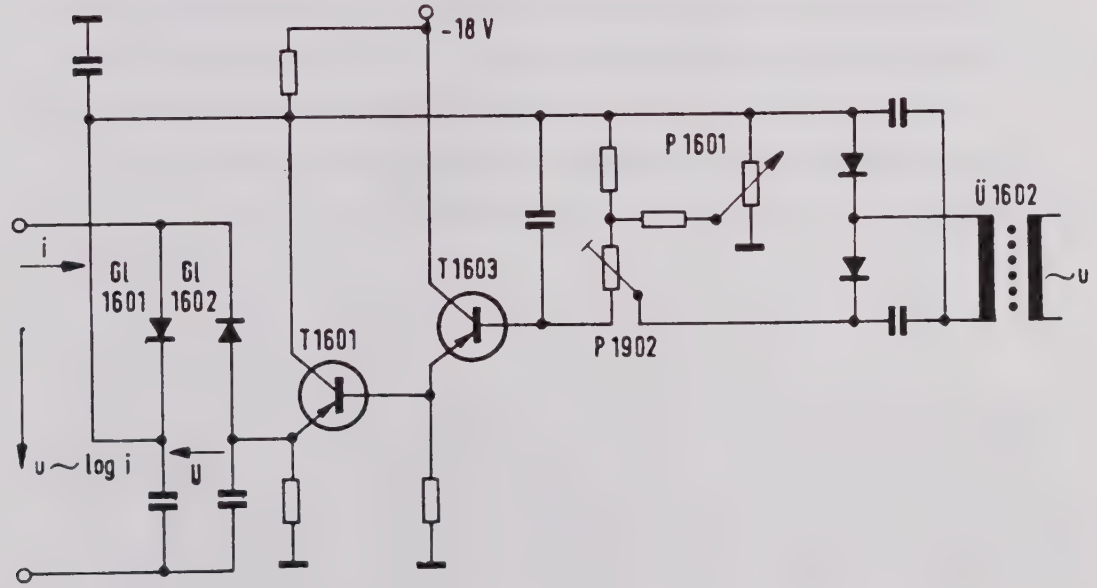



Fig. 18 DC amplifier and logarithmic diodes

Under calibrated conditions, the operating range will be completely within the logarithmic portion of the characteristic curve of the diodes. An increase of the slope of the charcteristic curve of the circuit can be made by adjustment of the amplification with trimmer potentiometer P 1902 (expansion) and the absolute position by inducement of a corresponding bias current with calibration potentiometer P 1601 (shift).
A bias current is fed to the output rectifier via relay 1601. This bias current suppresses the zero point of the meter and shifts the curvature of the logarithmic characteristic curve into an area below the measuring range during low level conditions.

### 2.3.18. Converter Oscillator for Single Sideband Demodulation (17)

This oscillator generates the carrier frequencies used for the demodulation conversion of SSB signals. Transistors T 1701 and T 1703 are combined in an emitter-coupled limiter circuit. T 1703 supplies a square wave current into the resonant circuit consisting of C 1705 and Ü 1702. The feed-back voltage at the base is sufficient to either completely open or block the transistor during a half-cycle. The resonant frequency of the circuit is 28 kHz, which can be increased by switching further inductances in parallel, to 29 kHz, 31 kHz or 32 kHz. These frequencies are selected with the aid of S 1701 and S 1801/6.
The current decoupled from the collector of T 1701 is fed to the demodulator circuit in the normal and inverted position. The current also flows continuously via transformer Ü 1701, the secondary of which consists of a voltage doubler circuit, where it is rectified. The common-base transistor T 1702 provides a potential-free current for the suppression of the meter zero point during logarithmic operation.

## 2.3.19. Switch Assembly and Level Switch (18)

The switch contacts are mainly used to switch the heater circuits of the gas-pressure relays. The PM-5 is, with the exception of the terminating resistor switching, fully equipped with this type of relays. The heater voltage of 3 V must remain within certain limits to ensure short switching periods (less than 1 sec.).
The number of energized relays depends on the selected mode and sensitivity of the level meter. Due to the max. current drain of 0.8 A a marked voltage drop would be caused at the various filter chokes, switch contacts, switches, etc. Resistors R 1802 to R 1805 are used as loads simulating the unenergized relays.
Various relay heater circuits are intercoupled with diodes (or transistors switched as diodes) in order to reduce the number of switch contacts. The other diodes placed before relays in series F and subsequent series are solely provided that the heater voltage is reduced by the value of the diode threshold voltage, thus ensuring that all relays obtain the same energizing voltage.

## 2.3.20. Main Distributor (19)

The main distributor possesses filter circuits for all of the voltages connections including the ground lead, originating in the RWO-5. This ensures that no interfering voltages can be induced into the PM-5 via the RWO-5 power supply cables. Choke L 1907 has a winding for each voltage so that the sum of the flowing currents is zero and that the core is not pre-magnetized or saturated.
The ground of the PM-5 is RF isolated from that of the RWO-5. The series circuit consisting of R 1915 and C 1908 suppresses any resonance of the transfer impedance between the two grounds.

## 2.3.21. Distributor 2 (20)

All sub-units of the tiltable chassis are supplied from this distributor with voltages obtained from the main distributor. This is carried out partly by means of a cable harness. The common-base circuit T 2001 represents a low impedance voltage source for the 69 MHz amplifier. The carrier balance of mixer I is aligned with the trimmer potentiometer P 2001.

## 2.3.22. Generating of Carrier Frequencies II to IV

The frequency conversion oscillators in the PM-5 must posses the same frequency accuracy and frequency stability as the control frequency of the RWO-5. They are, for this reason, locked to the same crystal-standard frequency. The 570 kHz crystal oscillator is synchronized by a 10 kHz square-wave voltage from the RWO-5. The two higher frequency oscillators operate at a harmonic of the lower frequency carrier. This allows the following conversion plan:

| | | |
|---|---|---|
| 4 th IF | = | 30 kHz |
| + 57 x 10 kHz = carrier IV | = | 570 kHz |
| 3 rd IF | = | 0.60 MHz |
| + 12 x carrier IV = carrier III | = | 6.84 MHz |
| 2 nd IF | = | 7.44 MHz |
| + 9 x carrier III = carrier II | = | 61.56 MHz |
| 1 st IF | = | 69.00 MHz |

### 2.3.22.1. Frequency Locking Device for 10/570 kHz (13)

This circuit compares the phase of the 570 kHz signal to the phase of the 57 th harmonic of the 10 kHz synchronizing signal. The frequency of the 570 kHz crystal oscillator is controlled, with a DC voltage, which is proportional to the phase difference. The phase comparison stage is so designed that the decoupling transistor T 1301 (PNP) only conducts when the positive half-cycle of one signal is present at the base of transistor T 1303 and the positive half cycle of the other signal to be compared is present at the emitter.

T 1301 will conduct for one half-cycle if both voltages are in phase. If the phase shift amounts to 180°, then both half-cycles will at no time be positive and the decoupling transistor will remain blocked. The relationship between conducting period and blocking period represents thus a direct measure of the phase shift. The conducting period of the decoupling transistor amounts to 1/57 of the 10 kHz half cycle, when referenced to the synchronizing frequency.

The 10 kHz square wave voltage originating from the RWO-5 is differentiated in the isolating transformer Ü 1301. The diode GI 1301 shorts the positive pulse, whereas the negative pulse causes transistor T 1302 to conduct.

Capacitor C 1303, which has been previously negatively charged via R 1302, is placed at ground potential during the negative pulse. A positive synchronizing pulse is fed to the emitter of the phase comparison stage. The pulse duration should not be longer than a half-cycle of the 570 kHz signal. If it were longer, a portion of the pulse would appear at the positive half-cycle. This would mean that the decoupling transistor would never quite be blocked and one could thus not take advantage of the voltage deviation at the collector. The current pulses through T 1301 charge capacitor C 1302, whose voltage is used to control the 570 kHz crystal oscillator. The control voltage is superimposed with a 10 kHz sawtooth voltage caused by the pulse type charge and the discharge via the load resistor R 1303. This sawtooth must be filtered out in a low-pass filter to avoid an undesired modulation of the 570 kHz signal. The common-collector stage comprising T 1304 also suppresses such a modulation and feeds the 570 kHz signal to the base of T 1303. The amplitude of this voltage has been so chosen that it is in its self not sufficient to unblock transistor T 1303.

### 2.3.22.2. 570 kHz Crystal Oscillator (12)

This oscillator generates carrier frequency IV which is used to control mixer IV. The frequency is locked to the 57th harmonic of the 10 kHz standard frequency of the RWO-5.

Since quarz crystal control is used it is only necessary to have a small hold range and the PM-5 could operate without a synchronizing signal, however, with a somewhat lower frequency accuracy.

The oscillator transistor T 1210 together with T 1209 form an emitter coupled limiter stage. T 1209 supplies the square-wave control current to mixer IV. A parallel resonant circuit comprising C 1226 and Ü 1203 is provided in the collector circuit of T 1210 to filter out the fundamental signal. This voltage is fed-back via various components from the secondary of the transformer to the base of T 1210. The magnitude is sufficient to fully drive the limiter.

The control magnitude is fed via a common emitter stage (T 1213) and is used as bias current for diode GI 1204. The diode can thus be shifted from the blocked into the conducting range. The effect on the oscillator frequency is explained in the following limit conditions:

When the diode is blocked, C 1229 is placed in series with the crystal and operates as a shortening capacitor, thus increasing the series resonant frequency. When the diode conducts, C 1229 will be shorted and the resonant frequency of the crystal is effective. All intermediate values are obtained in the transient areas. [1)]

Since the base current needed for T 1210 is in excess of the permissible crystal current the common-collector stage T 1211 is used for current amplification. The 570 kHz signal for the locking device is decoupled via the common-collector stage T 1212. The third harmonic of 1.71 MHz is decoupled across the resonant circuit consisting of C 1223 and Ü 1202. This represents the synchronizing frequency for the frequency locking of the 6.84 MHz oscillator.

2.3.22.3 Frequency Locking Device for 1.71/6.84 MHz (12)

This circuit essentially consists of the same phase comparison circuit as in the frequency locking device for 10/570 kHz. The 6.84 MHz oscillator is locked by means of the control voltage to the 12 th harmonic of the 570 kHz crystal frequency. The 1.71 MHz voltage is transformed into a square wave signal in the limiter. The coupling capacitor C 1217 slightly differentiates the signal and feeds it to the base of T 1204. The negative pulse is shorted by diode GI 1202 and the positive impulse is amplified in the common-emitter stage and passed via C 1215 as a negative pulse to the emitter of the two NPN transistors T 1202 and T 1203. Capacitor C 1216 has the effect of maintaining a constant pulse duration independent of the transistor tolerances. The 6.84 MHz current is fed via a common-base stage T 1202 to the input of the phase comparison stage. This ensures that the synchronizing voltage has no retroaction on the 6.84 MHz oscillator voltage. The phase shift of 90° will alway be effected in the control stage due to the fact that the phase relationships are evaluated, whereas the frequency is controlled.

---

1) In series A to C, the control voltage of the frequency locking device was fed directly to the varicap diode GI 1204. The base voltage of T 1209 serves in this case as inverse voltage. The series connection of the varicap diode and crystal together with their reactance, determine the 180° point and thus the the frequency of oscillation.

As is known, $\omega = d\varphi / dt$ is valid. The phase shift in the low-pass filter and output resistor of the decoupling transistor T 1202 must remain below 90°, otherwise an oscillation could occur within the hold range of the circuit if the ring amplification was sufficiently high. The charge capacitor C 1211 is placed across a resistor at the collector of the decoupling transistor T 1202 to neutralize this effect, which causes a retro-phase shift above the cut-off frequency of the RC link. It is true that capacitor C 1210 of the low-pass filter will be more quickly charged, but the charge is passed on to C 1211 from which the control voltage is taken. The second half of the low-pass filter is to be found in the subsequent sub-unit. Capacitors C 1130 and C 1206 complement the coil capacitance of the two low-pass filter coils so that attenuation peaks appear at 570 kHz and 1.71 MHz. These two frequencies are strongly contained within the synchronizing signal.

### 2.3.22.4. 6.84 MHz Oscillator (11)

This LC oscillator generates carrier frequency III for the control of mixer III and its frequency is locked to the 12 th harmonic of the 570 kHz crystal frequency.
The oscillator transistor T 1105 forms, in conjunction with T 1102, an emitter-coupled limiter stage. A parallel resonant circuit comprising transformer Ü 1103 is to be found in the collector stage of T 1105. The secondary of this transformer is used to feed-back a portion of the fundamental voltage to the base. The resonant circuit capacity and thus the oscillating frequency is controlled by a control voltage at the varicap diode GI 1101.
The third harmonic of the 6.84 MHz signal is filtered out at transformer Ü 1104 and is fed via the 20.52 MHz band-pass filter to the following frequency locking device. The square-wave current of transistor T 1102 flows via the common-base circuit T 1101 to mixer III and switches the transistors at the carrier frequency. The common-base circuit ensures that no interfering frequencies originating from the mixer can modulate side frequencies on to the carrier.

### 2.3.22.5. Frequency locking device for 20.52/61.56 MHz (10)

This stage comprises essentially the same phase comparison circuit as the frequency locking device for 10/570 kHz. The generated control voltage is used to lock the 61.56 MHz oscillator to the ninth harmonic of the 6.84 MHz oscillator.

The 61.56 MHz oscillator feeds transistor T 1101 via a common-base stage T 1004. The phase difference between the 61.56 MHz signal and the synchronizing pulse determines, which transistor of the phase comparison circuit is to pass the current if a simultaneous negative pulse is at the common emitter.
The synchronizing voltage is fed via the 20.52 MHz band-pass filter to the base of the swtiching transistor T 1002. The capacitor C 1005 is slowly charged via R 1003 and shifts the emitter potential so long in a positive direction until the synchronizing voltage at the base of T 1002 is sufficient to unblock the transistor during the positive half-cycle. The charge then rapidly flows via the phase comparison circuit. The discharge time constant of C 1005 is so chosen that the cycle repeats itself every third 20.56 MHz cycle. R 1004 operates as a damping resistor during the discharging of the capacitor on to the inductive emitter resistor of T 1002.

### 2.3.22.6 Oscillator and Limiter for 61.56 MHz (9)

This circuit generates carrier frequency II for the control of mixer II. The oscillator frequency is locked to the ninth harmonic of the 6.84 MHz oscillator frequency. The Hartley LC oscillator possesses a common-base stage for amplification. The resonant circuit voltage is decoupled via a capacitive divider and fed-back via R 901 to the emitter of T 901. The series connection of R 901 with the impedance of the common-base stage and the parallel resistor, represent the resonant circuit damping. The resonant frequency of the circuit is determined by the parallel-connected varicap diode GI 901. The limit of the hold range of this oscillator is so broad that a conventional RC low-pass filter can be used with the charging capacitor to form a filter network for the control voltage. The low-impedance and high Q of the resonant circuit also allow an increase of the signal-to-noise ratio. The low inductivity of coil L 901 is formed by a silver-plated metal bracket within a silver-plated casing.
The limiter stage comprising T 902 and T 903 is connected to a second capacitive divider of the resonant circuit and supplies a square wave current to mixer II and to the 20.52/ 61.56 MHz frequency locking device.

## 2.4. Scale Expander AZD-1

Application:

The scale expander allows portions of the meter scale (± 1 dB or ± 0.1 Np) to be spread over a length of approximately 100 mm. The attenuation range of the AZD-1 overlaps the 10 dB or 1 Np steps of the PM-5 level selector, ie. the range of indication for each position of the level selector amounts to -10 to +2 dB (-1 to +0.2 Np). Thus obtaining an overlap of 2 dB (0.2 Np)

Circuit:

The circuit consists of the differential amplifier T 1 and T 2, the two current amplification stages T 4 and T 5, the meter J 1 and the switchable attenuator R 9 to R 20.

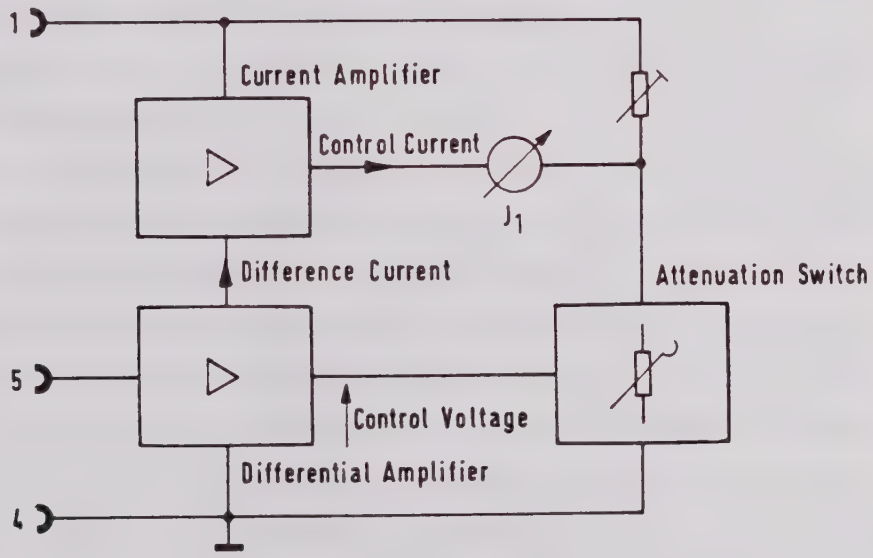



Fig. 19

The differential amplifier, current amplifier, meter and attenuator form a control circuit. A control current corresponding to the input voltage is used to bring the base voltage of T 2 to that at the base of T 1. This control is proportional to the input voltage and is indicated on meter J 1, which is calibrated in dB or Np. A complete balance of the differential amplifier is indispensable for a good linearity of the indication. The current must therefore be distributed equally between both transistors on driving the differential amplifier.

As one can see from the circuit, the series connection of the emitter diodes of T 4 and T 5 are placed in parallel to the collector resistor R 3. The two silicon threshold voltages (approx. 1.2 V) feed a constant current of approx. 10 µA via R 3 and thus via T 1.

Assuming that the differential amplifier is driven at the base of T 1, transistor T 2 would, due to the constant current in T 1, have to pass 9 times the current of T 1 if transistor T 3 remained blocked. This transistor takes over the excess current so that T 2 passes exactly the same amount of current as T 1. If the shunt transistor T 3, were not provided, a change in the base-emitter voltage would occur under the already mentioned drive conditions of T 2. An inconsistancy of the threshold voltages of T 1 and T 2 would on the other hand cause a non-linearity, i.e. a different expansion for the individual attenuator positions.

The differential amplifier must not load the AZD-output of the PM-5, because the meter voltage of the PM-5 must be indicated accurately with the AZD-1. This is the case, because the low collector current of T 1 (10 µA) demands a correspondingly low base current. Meter J 1 however, requires a current of 600 µA for f.s.d., which has led to the provision of the two current amplifying transistors (T 4 and T 5).

Small deviations of the base voltages of T 1 and T 2 are compensated for by control P 2 by injection of an inverse voltage at the base of attenuator resistors R 9 to R 20. These differences are caused by the different characteristic curves of the transistors.

P 3 is used to adjust the scale expansion. The potentiometer P 1 is used to adjust the absolute sensitivity and is externally accessable on the rear panel. Diode Gl 3 serves to provide temperature compensation for the zener diode Gl 4 and diodes Gl 1 and Gl 2 protect the meter against overloading. The capacitors C 1 and C 2 short any interfering signals present on the measuring signal.

## 2.5. Probe TK-8

The Probe TK-8 is used during measuring tasks, when it is desired to make low-capacitance measurements or if it is necessary to avoid mismatch errors.

The circuit consists of two main parts:

Part 1 is formed by the two isolating stages, which are installed in the probe tip.

Part 2 comprises an additional isolating stage and controls for the matching, frequency response and the residual attenuation adjustments. This part is to be found in the cylinder which is screwed directly on the PM-5 input. The two parts are interconnected by means of a 75 Ω cable.

The emitter resistor of T 1 is connected to the emitter of T 2. This ensures that equal-phase signals appear at both ends of R 4 and R 3, which, due to the common-collector stage amplification of $V \approx 1$, possess virtually the same amplitude. The result is that only very small alternating currents will flow through the two resistors and that the input impedance of T 1 will appear high-impedance.

R 1 is parallel to this input impedance and determines the magnitude of same in the lower frequency range.

The input capacitance remains at a constant 7 pF over the whole frequency range.

A protection diode Gl 1 is placed parallel to R 3, which ensures that the base-emitter paths of transistors T 1 and T 2 are not overloaded by large negative voltages. C 1 is provided to separate the measuring voltage from a superimposed DC voltage.

The diode Gl 1 is blocked during normal operation, by the threshold voltages of the two transistors. This diode has no effect on the frequency response or input capacitance because equal-phase signals appear at both ends.

Part 2 of the circuit is matched to the 75 Ω cable by means of P 1. This adjustment is made together with the frequency response alignment to obtain the most linear curve over the whole frequency range. Trimmer capacitor C 2 is used to align the frequency response of the probe to the Receiver PM-5.

Transistor 3 also operates as a common-collector stage and feeds the signal via C 4 to the receiver input. The input impedance of the PM-5 should be switched to position $R_e = \omega \frac{1}{C_e}$ during probe operation. The probe then possesses an attenuation of 2 dB (0.2 Np), which can be adjusted to its nominal value with the aid of P 2.

Diode Gl 2 protects transistor T 3 against excess voltages.

## 2.6. Return Loss Accessory RFZ-5

### 2.6.1. Measuring principle

The return loss accessory essentially represents a Wheatstone bridge. The bridge voltage is a measure of the reflection coefficient. The absolute correlation between receive voltage and reflection coefficient is given if the arrangment (generator, bridge and receiver) is calibrated for a certain reflection coefficient.

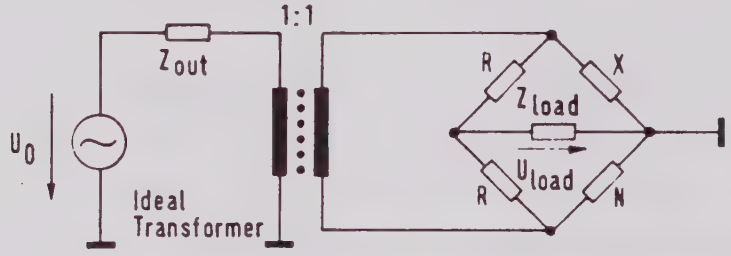



Fig.20 Bridge circuit

The following equation is valid for the indication voltage under the ideal conditions, ie. when the bridge is low-impedance fed and high-impedance loaded ($Z_{out} \rightarrow 0$ $Z_L \rightarrow \infty$)

$$U_L = \frac{1}{2} U_0 - \frac{N}{X+N} U_0$$

$$\frac{U_a}{U_0} = \frac{1}{2} - \frac{N}{X+N} = \frac{1}{2} \times \frac{X-N}{X+N}$$

This ideal dimension is especially unrealizeable at high frequencies.
For $Z_{out}$ or $Z_L$ values noticeably deviating from 0 or $\infty$ , the voltage $U_L$ is only directly proportional to the reflection coefficient under certain conditions of $Z_{out}$, $Z_L$, R and N.

The bridge must be matched to the generator output impedance and receiver input impedance of 75 Ω.
A satisfactory approximation of the ideal conditions of the bridge are obtained by resistive voltage division. This causes, however, a bridge attenuation of approx. 50 dB for p = 1. The sensitivity of the Measuring Set PSM-5 allows, in spite of this, return loss measurements up to 60 dB.

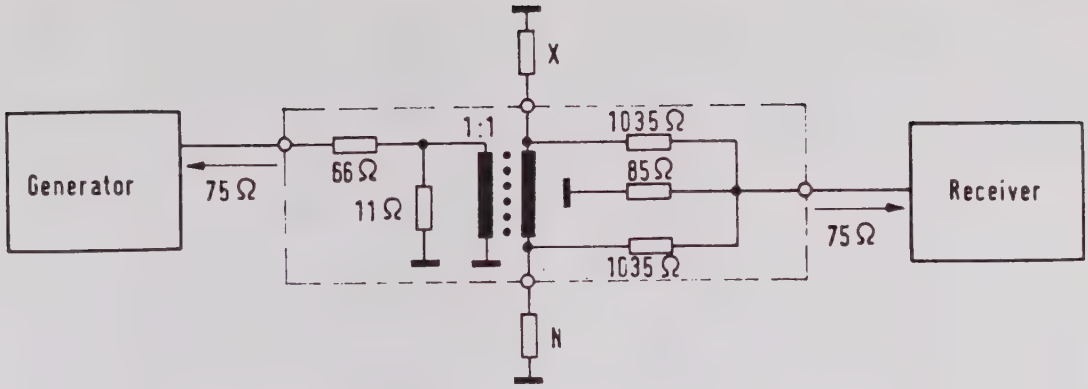



Fig. 21 Dimensioning of the bridge

The relationship of the resistors of the bridge have been calculated in such a manner, that a direct proportionality between $U_L$ and r exists at N = 75 Ω. An error occurs at all other resistive values, which is directly proportional to the magnitude of the reflection coefficient.

An error of r = 0.05 is obtained at N = 50 Ω and r = 0.086 at N = 150 Ω.

## 2.6.2. Circuit

The input attenuator provides a balanced output to avoid an unbalanced field distribution. Frequency response errors of the bridge, generator or receiver can be compensated for by capacitive alignment at C 101.

The auxiliary winding 5-6 is inversely poled to the primary winding 7 - 8, thus obtaining a symmetrical stray capacity distribution on the decoupling winding 3 - 4.

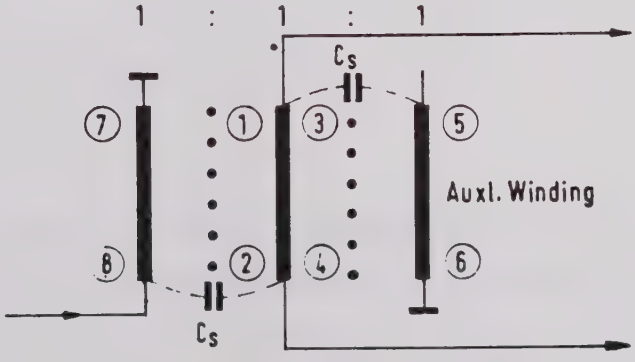



Fig. 22 Transformer Ü 101

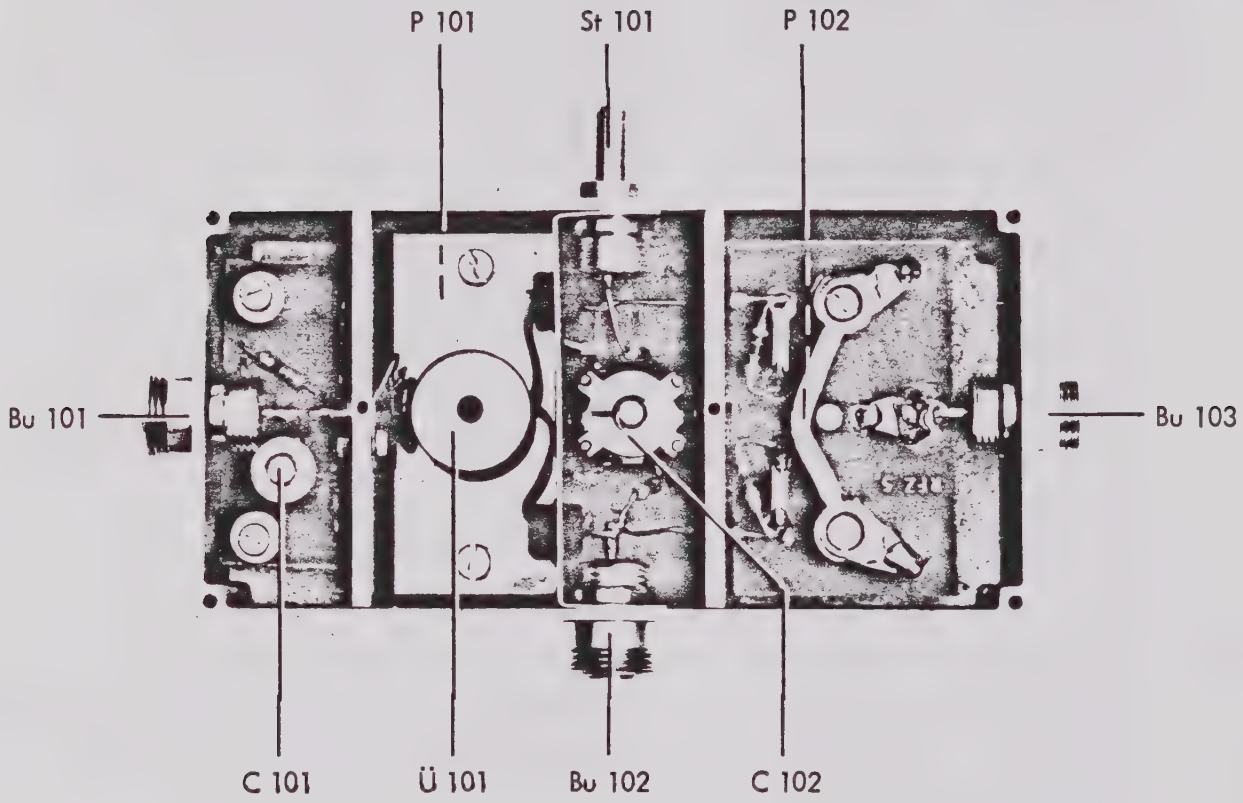



Bild 23 Reflexions-Meßzusatz

Fig. 23 Return Loss Measuring Accessory

The variable differential capacitor C 102 and potentiometer P 101 enable the bridge to be capacitively aligned. Resistors R 105 and R 106 neutralize a possible resonance between C 102, Ü 101 and the attached resistors or the test object.
The high impedance connection to C 103 has the effect of decreasing the capacitive load of the transformer and thus improving the frequency response of the bridge.
The terminating resistors R 111 and R 112 are also built up in a balanced condition to suppress any field unbalance and to ensure a low-inductive termination.
The bridge load impedance $Z_l$ is essentially formed by the relatively high impedance resistors R 109 and R 110 so that the bridge load impedance is high compared to its parallel impedance ($\approx$ R, see Fig. 20).

## 2.6.3. Reflection Standards

Standard resistors N with socket and plug connection together with calibrating resistors $R_{cal}$ are provided for the various impedance values of the PSM-5. The calibrating resistors cause a reflection coefficient $r = \frac{R_{cal} - N}{R_{cal} + N} = \pm 0.1$, corresponding to a reflection coefficient of 20 dB (2.3 Np).
The sign has been chosen so that the calibrating resistors are within the ranges 50 Ω to 75 Ω or 100 Ω to 150 Ω.

| Z / Ω | 50 | 60 | 65 | 75 | 135 | 150 |
|---|---|---|---|---|---|---|
| r | + 0.1 | + 0.1 | -0.1 | -0.1 | -0.1 | -0.1 |
| $R_{cal}$/Ω | 61.11 | 73.33 | 53.18 | 61.36 | 102.27 | 122.73 |

The parallel capacity, which results from the correct coaxial installation of the resistors, is compensated for by a series inductance.

## 2.6.4. Measuring Cable

A resistive transformation and thus a transformation of the reflection coefficient will take place, if the impedance of the measuring cable deviates from the necessary Z value. The maximum error thus occuring would be at a cable length of λ /8.
The 25 cm measuring cables are, however, sufficiently short and allow, in spite of this, a rational connection of the test object. Since it is necessary to use a 60 Ω cable for Z = 65, the error so caused will increase the reflection attenuation. Cable or adapter errors will add themselves to the error of the test object.

## 3. LIST OF THE REQUIRED MEASURING INSTRUMENTS

for fault finding and testing of the units

a) Common Instruments

| Instrument | Required Measuring or Frequency Range | Required Accuracy | Recommended Instruments | Manufacturer |
|---|---|---|---|---|
| DC Multimeter | 0 to 200 V<br>0 to 6 A | 1 % | UM, 100 kΩ/V | AEG<br>Gossen |
| Ohmmeter | 0 to 150 Ω | | Triohm | Gossen |
| Oscilloscope<br>with 10:1 probe | 0 to 33 MHz | Risetime<br>< 10 ns | OS-1<br>TK-4 | W.u.G.<br>W.u.G. |
| RF Millivoltmeter | 500 kHz to 105 MHz | ±3% f.s.d. | 411 A | hp |
| Frequency Counter | 10 Hz to 36 MHz | | FZ-2 | W.u.G. |
| Signal Generator | 10 Hz to 30 MHz | | MG-64 | W.u.G. |
| VHF Power Generator with Plug-In Unit | 0 dB<br>30 to 90 MHz<br>85 to 175 MHz | | LMS-68<br>LO-30<br>LO-85 | W.u.G. |
| Calibrated Attenuator | 0 to 120 dB<br>resp.0 to 12 Np | | FE-1 | W.u.G. |
| Wideband Voltmeter with probe | 10 Hz to 600 kHz | ±3% f.s.d. | SM-1<br>TK-1 | W.u.G. |
| Selective Level Meter | 10 kHz to 36 MHz | | PSM-5 | W.u.G. |
| Display Unit | | | SG-1 | W.u.G. |
| Plug-In Unit | | | SGE-10 | W.u.G. |
| Probe | 10 kHz to 36 MHz | | TK-8 | W.u.G. |
| DC Power Supply | 0 to 15 V | | Konstanter | Gossen |
| DC Power Supply | 0 to 36 V | | 6960 A | hp |

b) Special Instruments required for the Oscillator RWO-5

| Instrument | Required Measuring or Frequency Range | Required Accuracy | Recommended Instruments | Manufacturer |
|---|---|---|---|---|
| AC Multimeter | | | A $V_{eff}$ Multizet | Siemens |
| Resonant Frequency Meter | 30 MHz to 500 MHz | | WAM | R.u.S. |
| Standard Frequency Generator | 1 MHz | $< \pm 1 \cdot 10^{-6}$ | | |
| DC Ammeter | 0 to 10 mA | 0,5 % | AV, Gigant | Gossen |
| DC Power Supply with Current Limiter | 0 to 66 V/6 A | | TN-3 | W.u.G. |

c) Special Instruments required for the Generator PS-5

| Instrument | Required Measuring or Frequency Range | Required Accuracy | Recommended Instruments | Manufacturer |
|---|---|---|---|---|
| Level Generator with Fine-Tuning | 1 MHz | | TFPS-75 | W.u.G. |

d) Special Instruments required for the Receiver PM-5

| Instrument | Required Measuring or Frequency Range | Required Accuracy | Recommended Instruments | Manufacturer |
|---|---|---|---|---|
| LC Meter | 30 pF | | Type 130 | Tektronix |
| Scale Expander | dB resp. Np | | AZD-1 | W.u.G. |
| Level Standard | 0 dB, 100 kHz | | PN-27 | W.u.G. |
| Variable Voltage Divider | 75 Ω | | RT-1 | W.u.G. |

# 4. FAULT FINDING

## 4.1. Oscillator Portion RWO-5

### 4.1.1. Cabinet Removal and Access to the Sub-Units

The oscillator unit must be removed from its cabinet during the fault finding procedure. This is achieved by releasing the side-mounted holding screws and by removing the unit from the cabinet by means of the two handles.

Caution! Disconnect mains plug previous to removing the cabinet!

Stand the unit on the power supply side, the hinged chassis can now be opened by releasing two screws (see Fig. 24)
The following sub-units are now accessable:
Coarse frequency oscillator with auxiliary oscillator
Interpolation oscillator
Dial discs of the interpolation and coarse frequency oscillator (after removing the covering plate)
Amplifier and counter discriminator I
Counter discriminator II
The two 10 : 1 frequency dividers
The last four sub-units are plug-in boards and can be removed after releasing the holding screws.

Lock-in indication amplifier
This sub-unit is accessable after removing the 4 plug-in boards.
Caution! Both counter discriminators are fed from a common zener voltage. The zener diode is to be found in counter discriminator II. This means that counter discriminator I cannot be used without counter discriminator II.
Both 10 : 1 frequency dividers (12a) and (12b) are supplied with voltage via a common voltage dropper. Thus operation with only one board is not possible.
Since the two cards are completely identical, they may be exchanged.

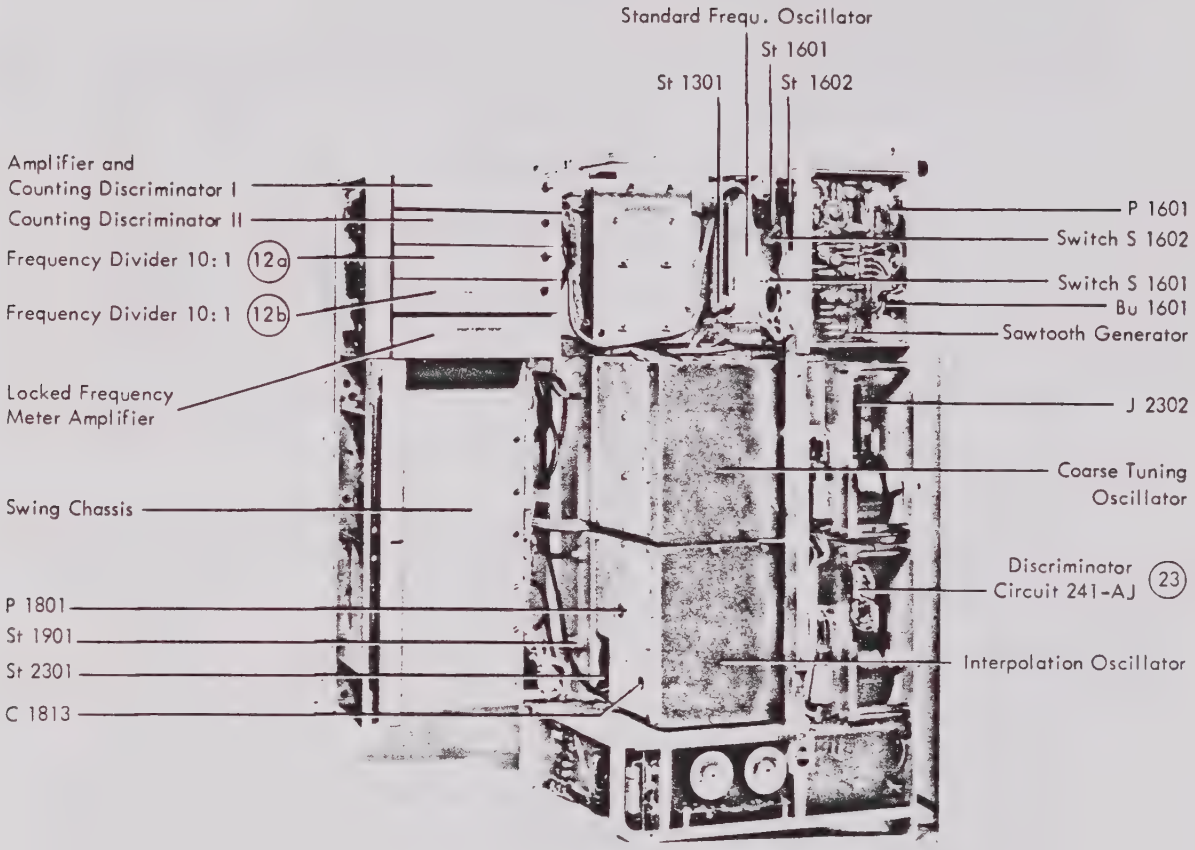



Fig. 24 Control Oscillator RWO-5 with Chassis swung open

### 4.1.2. Faults in the Power Supply

A fault can be assumed to be present in the power supply if after switching on, the projection dials remain unilluminated and no meter indication is observed with level control P 1002 fully clockwise.

Firstly it should be established if the correct mains voltage is provided. After this the fuses Si 2402, during mains operation, and Si 2401 during battery operation should be checked for continuity. In addition to this it is also necessary to examine the polarity of the battery during battery operation (Plus to point 4 or point 5 of socket Bu 2401). The following voltages should be measured against ground at the various test points on circuit board 241-AX1 "additional filtering" (rear of RWO-5), with a 100 kΩ/V DC voltmeter (Point 1 = ground):

| Point | Nominal voltage |
|---|---|
| 6 | +180 V |
| 5 | + 36 V |
| 3 | +6.3 V |
| 2 | - 3 V |
| 4 | - 18 V |

The plug-in power supply connections from receiver or generator should be removed if large deviations from the above nominal values are determined. If the given values are now indicated, this would indicate a fault in either generator or receiver. If however the deviation from the nominal value remains, then the fault will be within the power supply or in the Oscillator RWO-5.

A short circuit is indicated by an oscillation in the power supply.

(For details regarding the repair, please see the section "Checking and Alignment").

### 4.1.3. Malfunction of the Coarse Frequency Oscillator Locking indicator

Symptoms: a) No indication at Meter J 2302 on tuning the coarse frequency oscillator (Switch S 401 in "LOCKED" position).

b) Needle returns to the 1 MHz portion of the meter when a 100 kHz frequency locking has been selected.

c) Meter needle remains in the 100 kHz portion on tuning the coarse frequency oscillator, is however deflected to the right on passing a 1 MHz dial marker.

Possible causes: a) Non-operation of the internal standard frequency
Non-operation of the coarse tuning oscillator frequency
b) Non-operation of the 1 MHz reference frequency
c) Non-operation of the 100 kHz reference frequency

Checking of meter J 2302

Switch S 402 to its "FREE" position.

The meter needle should now indicate f.s.d.

Return switch to its "LOCKED" position.

a) Firstly check the internal standard frequency.
Connect an oscilloscope to the standard frequency output socket Bu 1303 of the RWO-5. Oscillogram 1 will be displayed if the standard frequency oscillator is operating correctly (see Section 6).
Measure the amplitude of the coarse frequency oscillator signal by means of a RF millivolt meter at point 1 of the phase meter (14) (241-AR).
Set coarse frequency oscillator to 36 MHz.
The amplitude should be in excess of 400 mV.

b) Connect an Oscilloscope via a 10 : 1 probe to point 2 of the phase meter.
Oscillogram 5 should be displayed.

c) Connect an Oscilloscope via a 10 : 1 probe to point 11 of the phase meter.
Oscillogram 7 should now be displayed (see Section 6). If signals 1, 5 and 7 are available at the correct amplitude and wave form, the following sub-units can be eliminated from the fault finding procedure: Standard frequency oscillator, standard frequency buffer stage and 10 : 1 frequency divider (12a).
For further fault finding within the sub-units Phase meter and indicator amplifier see Section "Checking and Alignment".

## 4.1.4. Malfunction of the Interpolation Oscillator Tuning Indicator

Symptom: No deflection at meter J 2301 on tuning the interpolation oscillator (S 1602 to position 1).

Possible causes: Non-operation of the 10 kHz reference frequency.
Non-operation of the Interpolation oscillator frequency.

Checking of meter J 2301

Switch sweep width S 1602 to position 3: the pointer of meter J 2301 should now indicate f.s.d. Return switch to position 1.

Connect an oscilloscope via a 10 : 1 probe to point 1 of the tuning indicator (19) 241-AA (top of RWO-5).

Oscillogram 10 should be displayed.

It is necessary to remove the generator and receiver from the cabinet during the following measurement. The generator and receiver portions can be removed as individual units after releasing the carrier, synchronizing and power supply cables and the mechanical interconnections.

After this, connect an oscilloscope to point 2 of the tuning oscillator and set the interpolation oscillator to the 0 dial marker.

Oscillogram 11 should now be displayed.

If both signals are correct, then the fault is to be found in the tuning indicator itself or in the subsequent discriminator (23) .

The tuning indicator can be assumed to be operating correctly if oscillogram 12 can be displayed at the collector of T 1906 and if a periodic frequency minimum can be noticed at point 5.

Printed circuit board "Discriminator" (23) 241-G is to be found in the upper portion of the cast cabinet of the interpolation oscillator below the "tuning indicator" circuit (top of RWO-5). This circuit is accessable after removing the screening of the "tuning indicator" by releasing the connection cables and the side-mounted holding screws, and removing the screening in an upwards direction. The discriminator indicator circuit is mounted directly at the rear of the locking indicator meter J 2301. The plug connections are accessable from the base of the RWO-5.

It is not necessary to release or remove anything from the discriminator during testing. A signal of $U_{rms}$ = 0.85 V and f = 1 kHz is fed via the disconnected lead to point 5 of the tuning indicator.

The plug connection at point 6 of circuit 241-AJ is disconnected. Connect point 6 via a current meter to ground.

The current meter should indicate 240 µA at an input frequency of 1 kHz. The current should rise to 340 µA on increasing the input frequency to 2 kHz.

### 4.1.5. Malfunction in the Generation of the Control Frequency

Symtoms: a) The control frequency deviates up to 500 kHz from the nominal value.

b) The control frequency deviates up to 70 kHz from the nominal value.

c) The control frequency deviates up to 4 MHz from the nominal value.

Note: The control frequency can either be measured at sockets Bu 103 or Bu 106 with a resonant frequency meter or in the form of a converted signal with the aid of a frequency meter at the output of the generator.

Possible causes:

a) The control stage for the frequency and phase control is inoperative. Relay 802 in the frequency and phase control (8) has not switched.

b) Fault in the phase control. Relay 801 or Relay 803 has failed to operate.

c) The differential amplifier T 801/T 802 of the frequency and phase control is overdriven. This could be caused by the non-operation of one of the two counter discriminators. The absence of one of the input signals for the counter discriminators could also cause this fault.

Fault finding:

a) Measure the energizing voltage of relay 802 with a DC multimeter at point 5 of the frequency and phase control (8) (241-AU). Place switch S 1602 to position 1. The energizing voltage should read approx. +5 V. If this voltage is not present, check diodes Gl 1605 and Gl 1606 at switch S 1602/II of the sawtooth generator (16)
If the relay is energized but the contacts not closed, then the relay should be exchanged.

b) Measure the voltage at point 2 of the frequency and phase control with a 100 kΩ/V DC multimeter. The reading must amount to +36 V if relay 801 has operated. Check contact rel 803 with a continuity meter.

c) The principle of operation of the unit requires that the difference between the frequencies of the control and coarse tuning oscillators always coincide to the frequency of the interpolation oscillator. It is thus necessary that the input frequencies of the two counter disciminators of an instrument also coincide.

Checking the generation of the interpolation frequency:
Measure the input signal of counter discriminator II at point 4 of the buffer and switching stage (21) with an oscilloscope via a 10 : 1 probe.
Place switch S 1602 to position 1 and set interpolation oscillator to dial marker 100.
Oscillogram 15 should now be displayed (see Section 6.1.)

Interpolation frequency range "x 10" :
Place switch S 1602 to position 2.
The switching stage is fed in this position with the unconverted frequency of the interpolation oscillator. Oscillogram 16 should now be displayed. If the signal exhibits the correct curve and amplitude, then the interpolation oscillator is operating correctly. The fault must therefore be in one of the sub-units: buffer and switching stage; frequency converter; 10 : 1 divider or 2.7 MHz oscillator.

Fault finding by signal tracing:
Take an oscillogram at point 2 of the 400 kHz low-pass filter (20) (241-D).
Oscillogram 13 should be displayed (see Section 6.1).
The 2.7 MHz signal, which is fed to the frequency converter (241-E), should now be checked. However, it is necessary to firstly disconnect the input of the converter (point 3) to avoid any retro-effect from the mixer. Oscillogram 14 should be displayed.
Reconnect the input connection.
The oscillogram at the collector of T 2102 should represent a sine wave signal of $U_{ss}$ = 1.8 V.

Finally oscillogram 15 should be displayed at the output of the buffer and switching stage (point 5), increased to the value of 2 germanium thresholds, ie. $U_{ss} = 4.6$ V.

Interpolation frequency range "x 1" :

Check the frequency conversion with the aid of a frequency counter at point 4 of the buffer and switching stage 241-H. Set the interpolation oscillator to dial mark 100. The counter should indicate 3.1 MHz with switch S 1602 in position 1 and 4 MHz if S 1602 is placed into position 2.

Checking of the difference frequency generation in the frequency converter (3) :

The measurement is carried out by connecting a frequency counter at the output (point 5) of converter (3) (241-Z). The frequency indication must correspond to the tuning of the interpolation oscillator.

If the interpolation oscillator is set at dial mark 100, the indication should jump from 3.1 MHz to 4 MHz on switching S 1602 from position 1 to 2.

The amplitude of the sideband should amount to approx. 40 mV.

If this is the case then the operation of the complete frequency and phase control has thus been completely examined.

If, however, the converter does not supply an output signal, it will be necessary to check the input signals.

Set the coarse frequency oscillator to 5 MHz and measure the signal of the control oscillator with an RF millivoltmeter at point 1 of converter (3) (241-AS). This should amount to 85 mV.

Measure the signal of the coarse frequency oscillator at point 2 of converter (3) (241-Z). Set the coarse frequency oscillator to 36 MHz. The nominal value should be at least 400 mV.

## 4.2. Generator PS-5

### 4.2.1. Complete Failure of the Unit

Symptoms: No meter deflection

No output level

Possible causes: Absence of the operating voltages.

Non-operation of the carrier frequency supply

Fault within the combination 69 MHz oscillator, amplitude modulator, 69 MHz amplifier

Fault within the combination of pre-amplifier and final amplifier.

#### 4.2.1.1. Checking the Operating Voltages

Measure the operating voltages at points 6 and 8 of the voltage filter network (12) (242-S) with a DC multimeter.

Nominal values: -18 V

+36 V

If the nominal values are obtained, it is then necessary to measure the total current consumption by placing ammeters into the leads to points 6 and 8 of the voltage filter network.

Nominal values: Point 6 : 390 mA

Point 8 : 120 mA

If these nominal values are not obtained, the fault can be localized by measuring the current consumption of the individual sub-units and by comparing them to the table given in Section "Checking and Alignment ".

#### 4.2.1.2. Checking of the Carrier Frequency Supply

The control frequency originating from the RWO-5, known here as the carrier frequency, is checked by measuring the input voltage at test point 3 (TP 3) of the limiter (11) (242-P). This should amount to 500 mV with the coarse tuning oscillator of the RWO-5 set at 0 MHz.

## 4.2.2. Checking of Limiter (11)

The output voltage of the limiter is measured at the input (TP 1) of converter (5) (circuit board 242-D).

The nominal value is approximately 425 mV.

If this value cannot be measured, then a fault in the limiter is indicated, whereby the following should noted:

If the collector currents of the two difference amplifier stages are unbalanced, large deviations may be observed between the collector currents of T 1122 and T 1125.[1)]

Since it is difficult to differentiate between a blocked and a defective transistor, the following measures are recommended:

-18 V is fed via 12 kΩ to the base of T 1121 if $U_{coll}$ of T 1122 = 0 V

The base of T 1121 is connected via 5 kΩ to ground if $U_{coll}$ of T 1121 ≈ -3 V.

The collector voltage of T 1122 must shift to the opposite extreme value in both cases if both transistors are in order.

Likewise T 1124/T 1125 [1)].

The base of T 1121 is connected via 5 kΩ to ground if $U_{coll}$ of T 1125 = 0 V.

-18 V is fed via 12 kΩ to the base of T 1125 if $U_{coll}$ of T 1125 ≈ - 0.65 V

The control cable from the generator portion should be removed from socket Bu 1101 of the RWO-5 during these checks.

The limiter curves given in the following diagram can be of assistance when fault finding (Fig. 26).

The curves were measured with the following measuring arrangement:

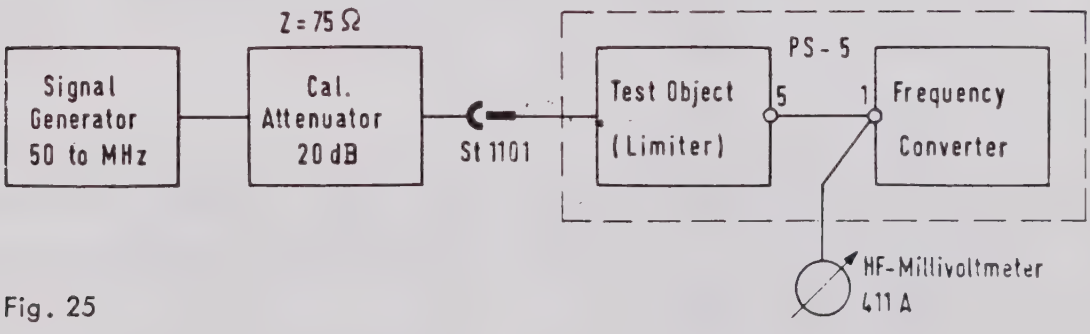



Fig. 25

1) For production series A to D the transistors were issued with the following annotations:

| Series E... | T 1121 | T 1122 | T 1123 | T 1124 | T 1125 |
|---|---|---|---|---|---|
| Series A...D | T 1101 | T 1102 | - | T 1103 | T 1104 |

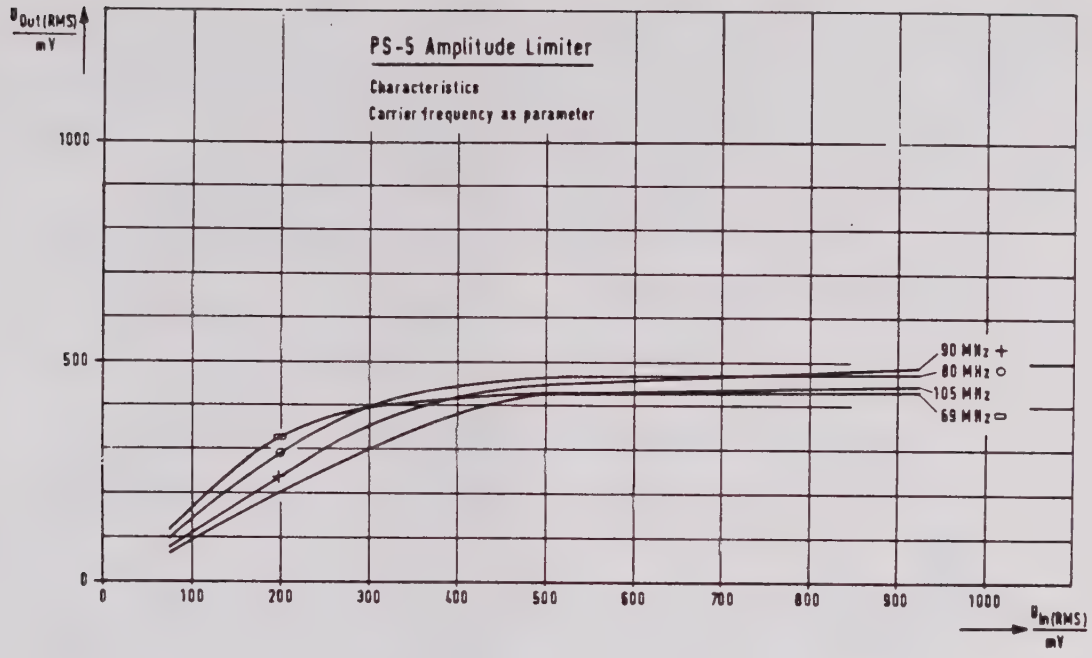

PS-5 Amplitude Limiter
Characteristics
Carrier frequency as parameter
$U_{Out(RMS)}$ mV
1000
500
0
0
100
200
300
400
500
600
700
800
900
1000
$U_{In(RMS)}$ mV
90 MHz +
80 MHz ○
105 MHz
69 MHz ▭

Fig. 26

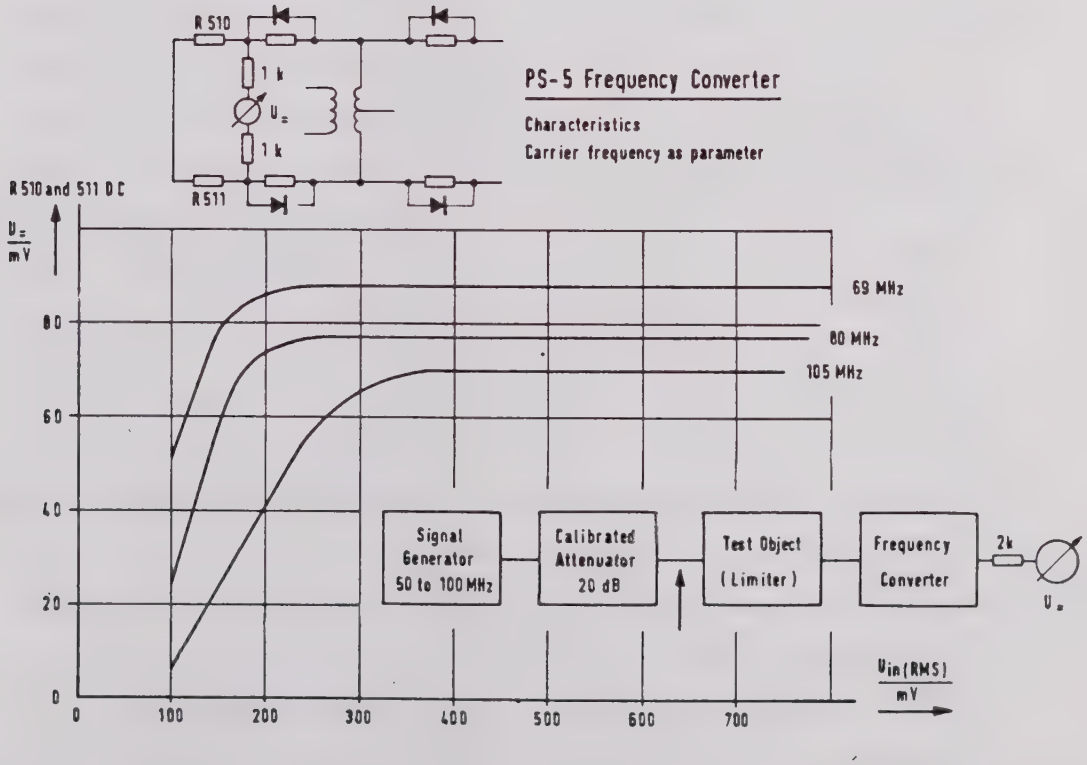

R 510
1 k
$U_=$
1 k
R 511
PS-5 Frequency Converter
Characteristics
Carrier frequency as parameter
R 510 and 511 DC
$U_=$ mV
80
60
40
20
0
0
100
200
300
400
500
600
700
$U_{in(RMS)}$ mV
69 MHz
80 MHz
105 MHz
Signal Generator 50 to 100 MHz
Calibrated Attenuator 20 dB
Test Object (Limiter)
Frequency Converter
2k
$U_=$

Fig. 27

## 4.2.3. Checking of the Frequency Converter (5)

The operation of the frequency converter can be checked by measuring the voltages across the balancing resistors R 516/R 517 and R 510/R 511.

These voltages serve as a relative value of the supplied carrier power.

The 1 kΩ resistors in series with the meter neutralize any effects which could be caused by the capacity of the meter itself.

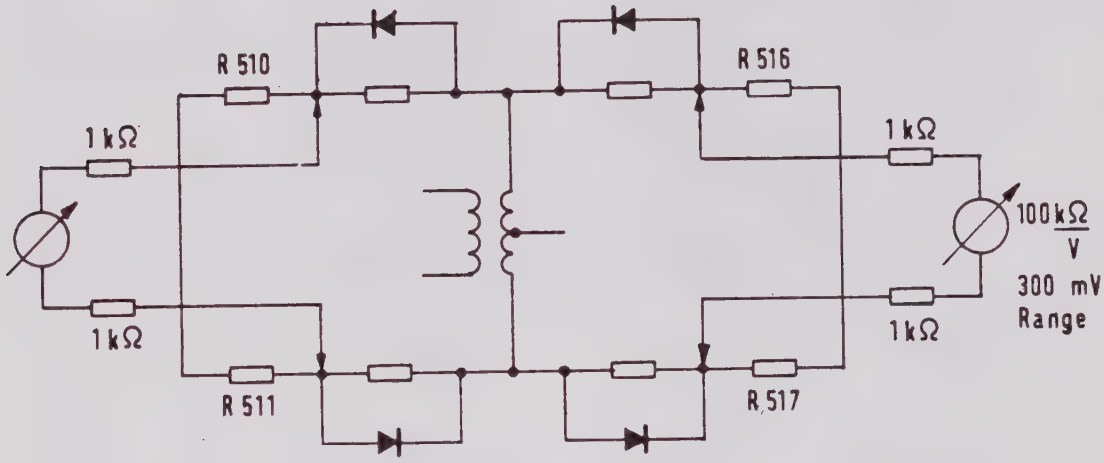



Fig. 28

The sideband attenuation 20 log $\frac{U\,\omega}{U_{\Omega-\omega}}$ amounts to 20 dB.

This is measured as follows:

Measure U ω with an RF millivoltmeter at TP 3 of the 69 MHz, amplifier (4) (242-B) and adjust to read exactly 70 mV with potentiometer P 1002.

Measure the $U_{\Omega-\omega}$ signal at the low-pass filter output TP 1 of the preamplifier (7) (242-F).

Nominal value: 8.8 mV.

Adjust the coarse frequency oscillator of the RWO-5 to 1 MHz and the interpolation oscillator to 0 kHz.

Measure the sideband signal $U_{\Omega-\omega}$ at TP 1 of the preamplifier.

Nominal value: 1 MHz.

Fig. 27 of the curve sheet page 85, shows the characteristic curves of the frequency converter. The difference between the individual DC voltages in the limited portion is caused by the frequency response of the amplifier stage within the converter togetner with its transformers.

If the sideband frequency at the output of the low-pass filter also returns to 0 in the zero setting of the two RWO-5 oscillators, it can be assumed that the combination of 69 MHz oscillator, amplitude modulator and 69 MHz amplifier is operating correctly.
If no signal is obtained at the output of the unit (output II) with the correct sideband signal at the low-pass output, the fault should be found in the combination of pre-amplifier or final amplifier.
If the sideband signal is not present, the fault finding should be concentrated to the combination 69 MHz oscillator, amplitude modulator and 69 MHz amplifier.

### 4.2.4. Malfunction in the Combination 69 MHz Oscillator, Amplitude Modulator and 69 MHz Amplifier

#### 4.2.4.1. Checking the 69 MHz Oscillator

Measure the output level of the 69 MHz oscillator (1) with a RF millivoltmeter at test point 1 (circuit board 242-R)
Nominal value: $\geqq 1.7$ V

#### 4.2.4.2. Checking the 69 MHz amplifier

Measure the input level of the 69 MHz amplifier (4) at test point 1 (circuit board 242-B), whereby the level potentiometer should be fully advanced.
Nominal value: $> 50$ mV.
Reduce the input level with P 1002 to 20 mV and measure the output level of the 69 MHz amplifier at test point 3.
Nominal value: 110 mV.

#### 4.2.4.3. Instructions for Fault Finding in the 69 MHz Amplifier

A DC measurement cannot be used to establish whether one of the two transistors, T 402 or T 403, are defective.
It is possible, due to the different characteristic curves, that in the absence of an AC input signal one transistor takes over the whole current, whereas the other is blocked. Therefore, if one of the two emitter voltages is equal to the voltage at the connection of R 409 and R 410, a further test should be made to establish whether an unfavourable pairing prevails.

If, for instance, T 403 blocks, a 1 kΩ resistor is placed in parallel to C 405, thus generating approximately 40 mV across R 407. T 403 should now conduct. If, however, T 402 is blocked, a 2.7 kΩ resistor is placed between point 1 of the circuit and the connection point of R 407 and R 408, whereafter T 402 should conduct.

A further simplification of the fault finding is by measuring the voltages given in the following diagram. The frequency converter is connected as load but does not receive a carrier signal. A RF millivoltmeter is used for the measurement.

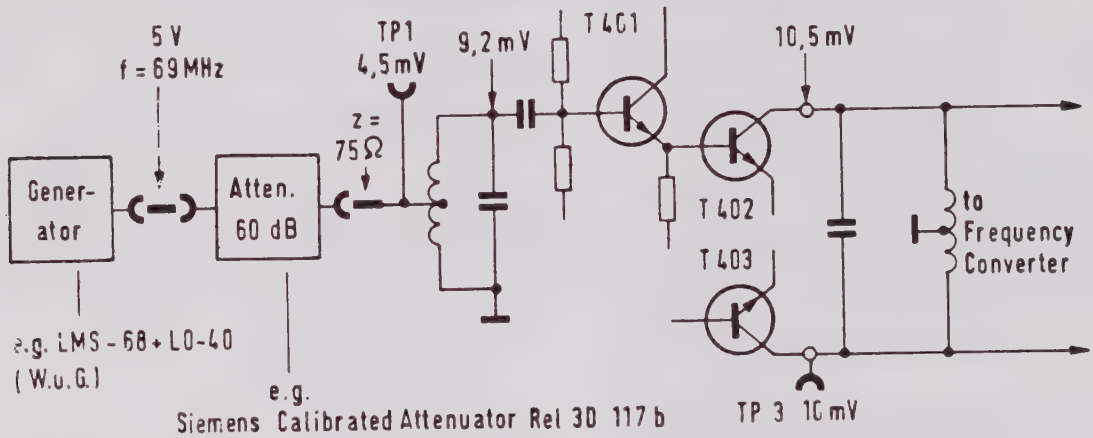



Fig. 29 69 MHz Amplifier

The overall sensitivity can be measured using the same measurement arrangement, by increasing the input voltage at TP 1 until a voltage of, for instance, 300 mV is measured at the output TP 3.

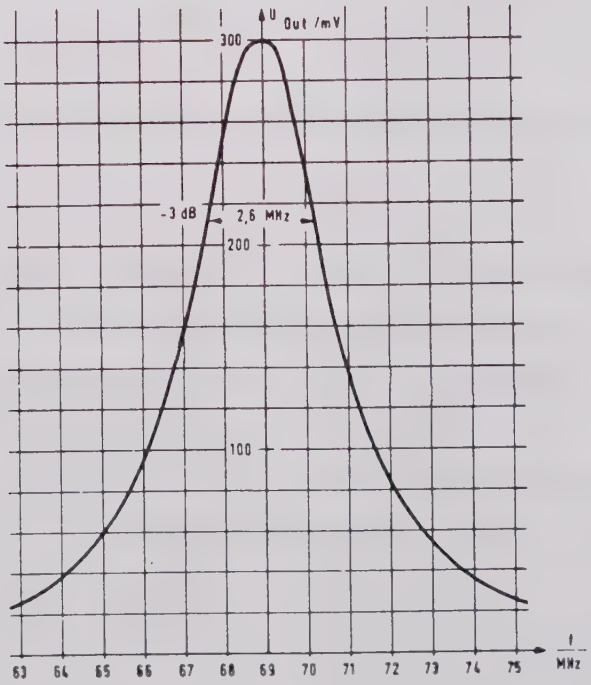



Fig. 30

## 4.2.5. Malfunction in the Combination of Pre-amplifier and Final amplifier

This combination can be checked by carrying out an amplification measurement.

Adjustment at the RWO-5: Interpolation oscillator to 0 kHz

Coarse frequency oscillator to 1 MHz

### 4.2.5.1. Amplification of the Pre-amplifier

Adjust the voltage at test point 1 of the pre-amplifier (7) (circuit board 242-F) with potentiometer P 1002 to 10 mV.

Measure the voltage at test point 2 of the pre-amplifier.

Nominal value: 282 mV

### 4.2.5.2. Amplification of the Final Amplifier

Adjust the voltage at test point 2 of the pre-amplifier with Potentiometer P 1002 to 100 mV.

Terminate socket Bu 802 with 75 Ω.

Measure the voltage at Bu 802 (Output II).

Nominal value: 325 mV

Additional values of interest during fault finding:

Pre-amplifier

Amplification at low frequencies: 26.9 to 30.9 dB; average: 28.9 dB

Final amplifier

Amplification at low frequencies (Bu 802 terminated with 75 Ω):

10 to 10.6 dB; average: 10.3 dB

Recommended input voltage to avoid over driving: 100 mV

The following curve represents the frequency response of the final amplifier:

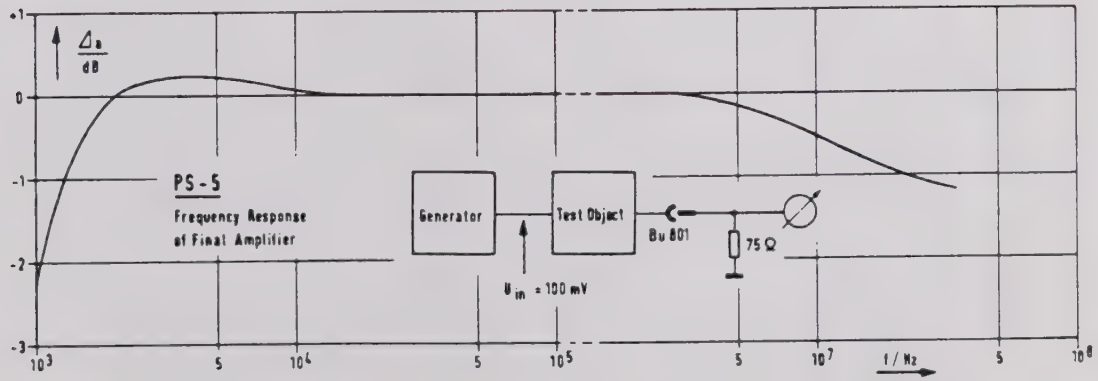



Fig. 31

### 4.2.6. Failure of the Phase Control

Symptoms: A failure of the phase control is not visable at the generator. This could cause some difficulty when operating the unit as PSO-5. However, since a synchronously tuned receiver portion is mostly connected to the output of the test object, the failure can be noticed immediately, because the meter in the receiver portion will not be actuated.

Possible causes: Absence of the 1 MHz synchronizing frequency from the RWO-5
Failure of the phase meter
Failure of the hunting oscillator

#### 4.2.6.1. Checking the Synchronizing Frequency

Connect an oscilloscope via a 10 : 1 probe to point 7 of the phase control (2) (circuit board 242-E) and check the 1 MHz synchronizing signal.
Oscillogram 2 of the RWO-5 should be displayed but with a shorter rise time (see section 6.)

#### 4.2.6.2. Checking the Hunting Oscillator

Disconnect the synchronizing cable at socket Bu 1102 of the RWO-5.
Connect an oscilloscope to point 5 of the phase control and check the output signal of the hunting oscillator. Oscillogram 19 should be displayed. Connect a 68 kΩ resistor from point 5 to ground. The oscillation of the hunting oscillator should cease. Reconnect the synchronizing cable.

#### 4.2.6.3. Checking the 69 MHz Signal

Measure the oscillator signal at the emitter of T 205.
Nominal value: 0.5 to 0.7 V
If it is evident that all signals are present in correct quantity and waveform, and that the hunting oscillator is operating, it is then necessary to check the phase control itself.

#### 4.2.6.4. Checking the Phase Control

Check the pulse shaper stage T 201/T 202 and transformer Ü 201.

Connect an oscilloscope via a 10 : 1 probe to the following points and compare with the relative oscillograms in Section 6:

Collector of T 202: Oscillogram 20

Primary of Ü 201, between 1 and ground: Oscillogram 21

Secondary of Ü 201, between 6 and ground: Oscillogram 22

Secondary of Ü 201, between 3 and ground: Oscillogram 23

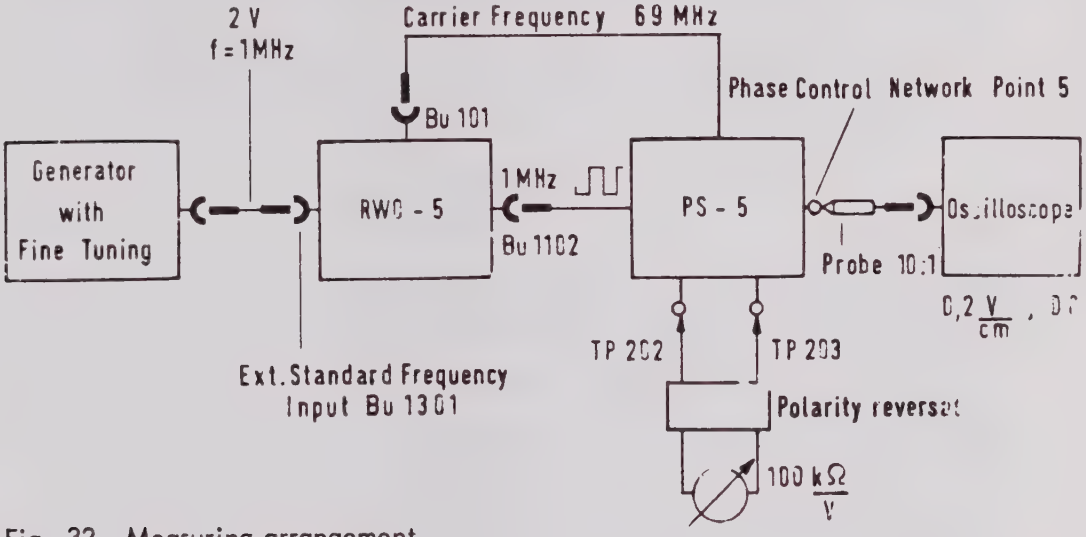



Fig. 32 Measuring arrangement

The external generator frequency of 1 MHz replaces the internal 1 MHz standard frequency. This is possible because the internal 1 MHz standard frequency of the RWO-5 is switched off on connecting a generator to socket Bu 1301.

It is then possible to alter the 1 MHz synchronizing frequency for the generator with the fine tuning and to thus measure the hold and pull-in range of the generator phase control.

The hunting oscillator is non-operative within the hold range and the voltmeter and oscilloscope will indicate a DC voltage which increases with the advancing detuning from 1 MHz.

Since the DC voltage can be of negative or positive polarity, a polarity reversal has been placed before the meter.

4.2.6.5. Hold and Pull-in Range of rhe Phase Control

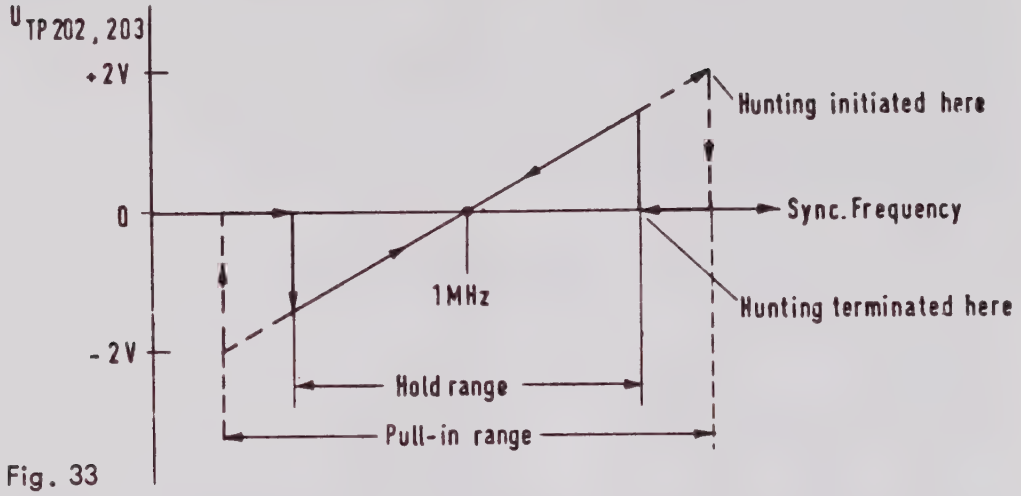



Fig. 33

If the detuning of the synchronizing frequency is increased further, the pull-in range will be left, the hunting oscillator will commence oscillation and the DC voltage will return to 0 V. If the detuning direction is reversed, the hunting oscillator will cease oscillation on reaching the hold range and the DC voltage will jump to a value in the same order of magnitude of that measured at the pull-in range limits.

Nominal value for the hold range: $\geqq \pm 2.5$ kHz

4.2.7. Malfunction of the Indicator Circuit or Control Amplifier

Symptoms: a) No meter deflection

b) Meter needle at f.s.d.

Possible causes: a) Short or open circuit of one of the two indicator rectifiers GI 801 or GI 802.

b) Transistor T 1006 has short or open circuit.

4.2.7.1. Operational Check of the Indicator circuit and the Control Amplifier

Set the coarse frequency oscillator of the RWO-5 to 1 MHz.

Connect the generator portion as normal.

Place a dummy plug into socket Bu 1001 (or insert a normal banana plug into the centre hole of the socket). This disconnects the amplitude control, ie. the connection between T 1003 and T 1004 is broken.

Switch S 1001 to "VOLTAGE LEVEL"

Disconnect the carrier signal by removing St 1101 from socket 101 of the RWO-5.

The output level should now return to zero.

The meter needle should be directly at the mechanical zero point (correct if necessary with P 1004). [1)]

Reconnect carrier signal.

Measure the voltage at socket Bu 802 with a RF millivoltmeter and adjust to 1.55 V with P 1002.

The built-in meter should now show a reading of 0 dB (0 Np) (correct if necessary with P 802).

### 4.2.8. Malfunction of the Amplitude Control

Symptoms: The meter indicates a level reduction of 4.5 dB (0.5 Np), on placing the "$R_i$ / Ω" switch S 902 from 50 Ω to 150 Ω in the "POWER LEVEL" mode, whereas the output level remains constant.

Possible causes: The control stage is open circuit (socket Bu 1001 is defective).

#### 4.2.8.1. Operational Check of the Amplitude Control

The meter reading should be adjustable between approximately zero and f.s.d. with level potentiometer P 1002.

Place switch S 1001 to "POWER LEVEL" and "$R_i$ / Ω"

Switch S 902 to 150 Ω.

Measure the output amplitude at socket Bu 802 at a meter reading of 0 dB (0 Np) with a RF millivoltmeter.

Nominal value 2.45 V (2.11 V)

The output amplitude must be progressively lower at each position on switching from $R_i$ = 150 Ω to $R_i$ = 50 Ω and should have a value of 1.42 V (1.22 V) at $R_i$ = 50 Ω, if 0 dB (0 Np) has be reset.

The reading on the built-in meter should, however, only increase by approximately 0.7 dB (0.07 Np).

---

1) Commencing with series G (or series F if J 1001 accords to Bv 242-8104 and 242-8105) : Connect 100 kΩ/V DC voltmeter parallel to R 1016. Select 300 mV range and adjust P 1004 until 75 mV reading is obtained. Caution! The reading should increase on clockwise rotation of P 1004.

4.2.8.2. Control Amplification of the Amplitude Control

Fig. 34 Measuring arrangement

Switch "$R_i$ / Ω" switch to 75 Ω. Place switch S 1001 to" POWER LEVEL".

Adjust the output level with potentiometer P 1002 to read 0 dB (0 Np).

The voltage indicated on the wideband voltmeter should be ≦ 1 mV in the absence of a drive signal from the signal generator. Set generator to 10 Hz and an output level of 2 V.

Disconnect the amplitude control with the dummy plug.

Adjust P 1002 for a 0 dB (0 Np) reading.

Note the voltage $U_1$ at the voltmeter. Reconnect amplitude control by removing dumming plug and readjust P 1002 for a 0 dB (0 Np) reading. Note voltage $U_2$ at the RF voltmeter.

Calculate the control amplification: $\frac{U_1}{U_2}$

Nominal value: 32 dB
Repeat measurement at -10 dB (- 1 Np)
Nominal value 26 dB.

4.2.9. Malfunction of the Attenuator

Symptom: Incorrect attenuation

Possible causes: Reed contact defective. Diode in diode switch defective.

Operational control of the attenuator

The attenuator consists of four selectable and combinable L pads.

From left to right: 20 dB / 10 dB / 20 dB / 20 dB
2 Np / 1 Np / 2 Np / 2 Np

Connect a level meter (eg. PM-5) to the attenuator output socket Bu 901, set the attenuator to 0 dB (0 Np) and adjust the amplitude control for a reading of 0 dB (0 Np) on the connected level meter.

Switch the attenuator to each of the positions and observe the attenuation increase at the receiver. If this does not correspond to the attenuator position, the check should be ceased. The following table indicates which relays are operative in the individual attenuator positions.

| Attenuator position | 20 dB pad (2 Np pad) | 10 dB pad (2 Np pad) | 20 dB pad (2 Np pad) | 20 dB pad (2 Np pad) |
|---|---|---|---|---|
| 0 dB (0 Np) | rel 901 | rel 903 | rel 905 | rel 907 |
| -10 dB (-1 Np) | rel 901 | rel 904 | rel 905 | rel 907 |
| -20 dB (-2 Np) | rel 902 | rel 903 | rel 905 | rel 907 |
| -30 dB (-3 Np) | rel 902 | rel 904 | rel 905 | rel 907 |
| -40 dB (-4 Np) | rel 902 | rel 903 | rel 906 | rel 907 |
| -50 dB (-5 Np) | rel 902 | rel 904 | rel 906 | rel 907 |
| -60 dB (-6 Np) | rel 902 | rel 903 | rel 906 | rel 908 |
| -70 dB (-7 Np) | rel 902 | rel 904 | rel 906 | rel 908 |

Measure the voltage across the coils of the relay that should be energized in the malfunctioning position.

If the voltages are present, the contacts should be checked for continuity.

If a voltage is absent, this will indicate a defective diode.

The following table shows the diodes which are in circuit in the individual attenuator positions.

| Attenuator position | Gl 901 | Gl 902 | Gl 903 | Gl 904 | Gl 905 | Gl 906 | Gl 907 | Gl 908 | Gl 909 | Gl 910 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 dB | | | | X | | | | X | | |
| -10 dB | | | | X | | | | X | | |
| -20 dB | X | | | | X | | | | X | |
| -30 dB | X | | | | X | | | | X | |
| -40 dB | | X | | | | X | | | | X |
| -50 dB | | X | | | | X | | | | X |
| -60 dB | | | X | | | | X | | | |
| -70 dB | | | X | | | | X | | | |

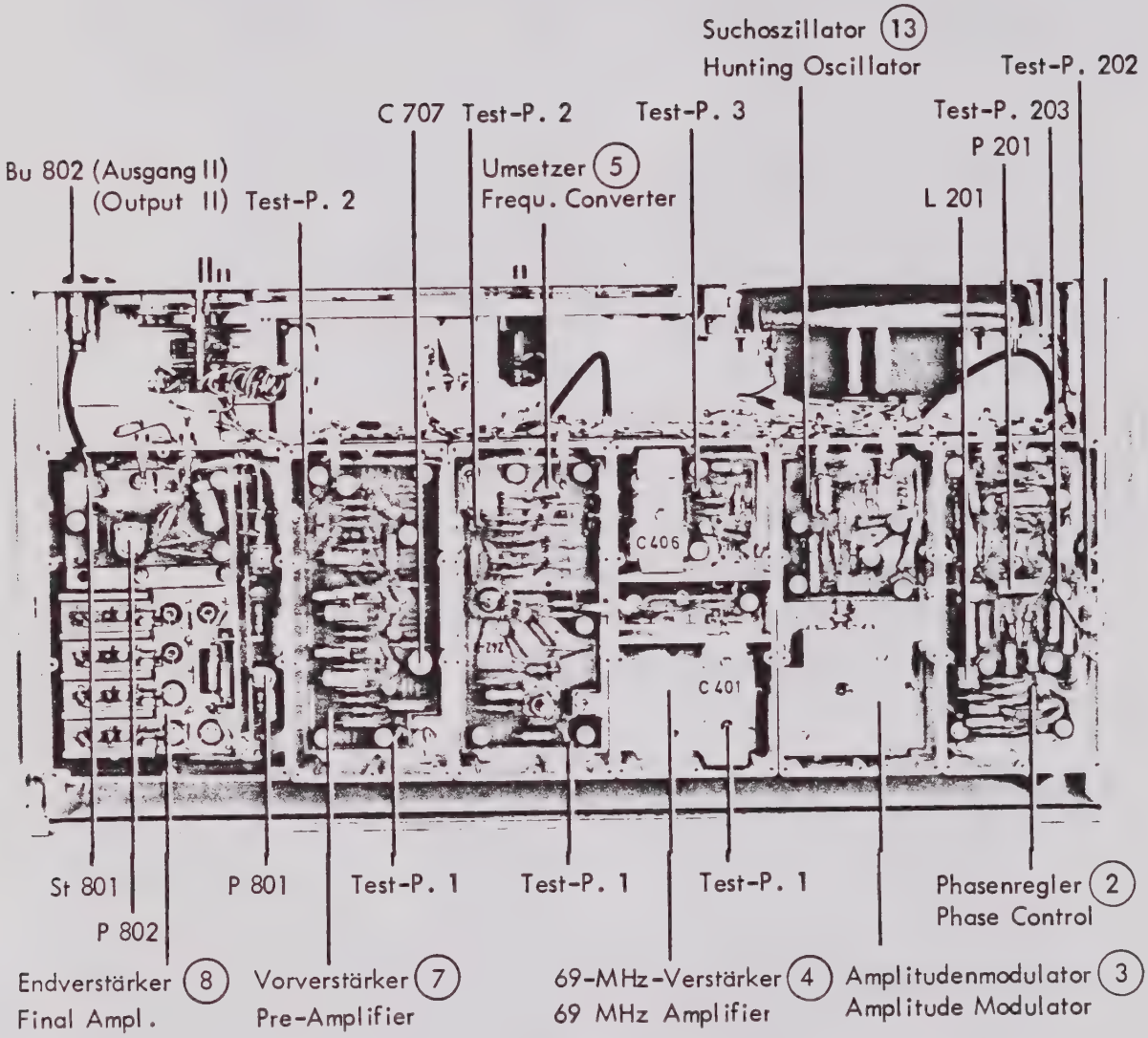



Bild 35 PS-5 Ansicht von oben
Fig. 35 PS-5 Top View

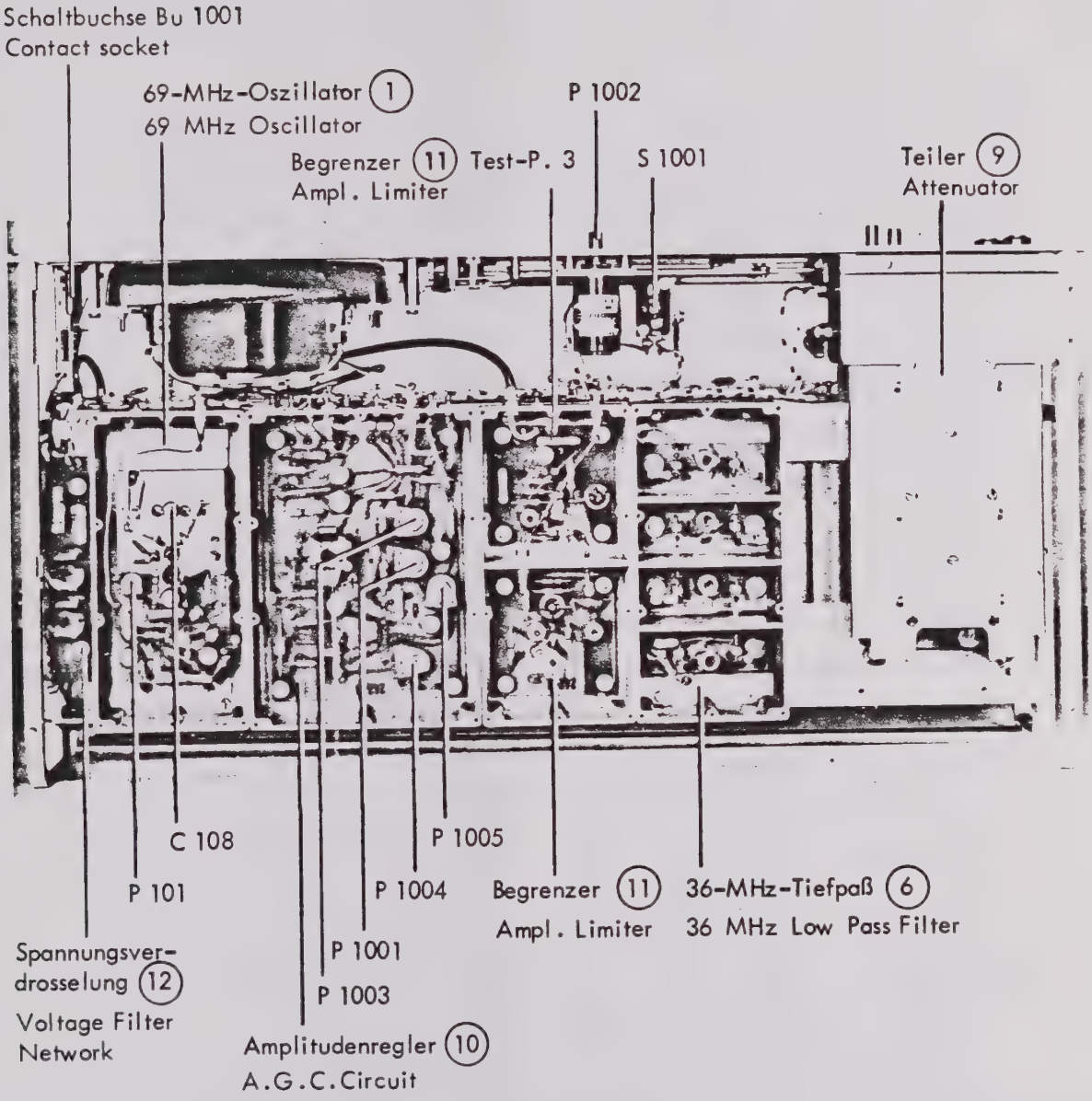



Bild 36 PS-5 Ansicht von unten
Fig. 36 PS-5 Bottom View

## 4.3. Receiver PM-5

It is important for the fault finding and repair that the function of the receiver as a whole and of the individual subunits is known (see Section 2.3. of this Service Manual).

A total failure of the unit is indicated by the following symptoms:

a) No meter indication and absence of PM-5 output voltage in calibration linear position, with the RWO-5 tuning at 100 kHz.

b) The level originating from Generator PS-5 is not received.

In order to rapidly establish the faulty subunit, the unit should be examined as follows.

Remove the PSM-5 or PMO-5 from its cabinet.

All components are accessable on the hinged chassis of the PM-5.

The cause of the fault can be localized to one or a small group of sub-units by checking the operating voltages (see 4.3.1) and the voltages at the various test points (see 4.3.2).

If the receiver malfunction is only present in one mode, this usually indicates the defective sub-unit, whereby the correct operation of the change-over relays should be checked against Section 4.3.3. or the relay plan.

A large carrier unbalance at mixer I (see 4.3.4.) can cause a malfunction of the unit at low receive frequencies.

Further assistance can be had by checking the DC operating points against the relative values given in the circuit diagram, comparing the levels obtained to those given in the level plan and by making oscillograms. Specific measurement values are contained in Section 5. "CHECKING AND ALIGNMENT" .

The position of the various printed circuit boards, and the trimmers and potentiometers contained therein, is shown in the internal views of the unit.

If the receiver is operating correctly, a meter reading amounting to -7 dB ± 2 dB (-0.8 Np ± 0.2 Np) should be obtained in the linear calibration position (red triangle) with the calibration potentiometer P 1501 in its fully anticlockwise position.

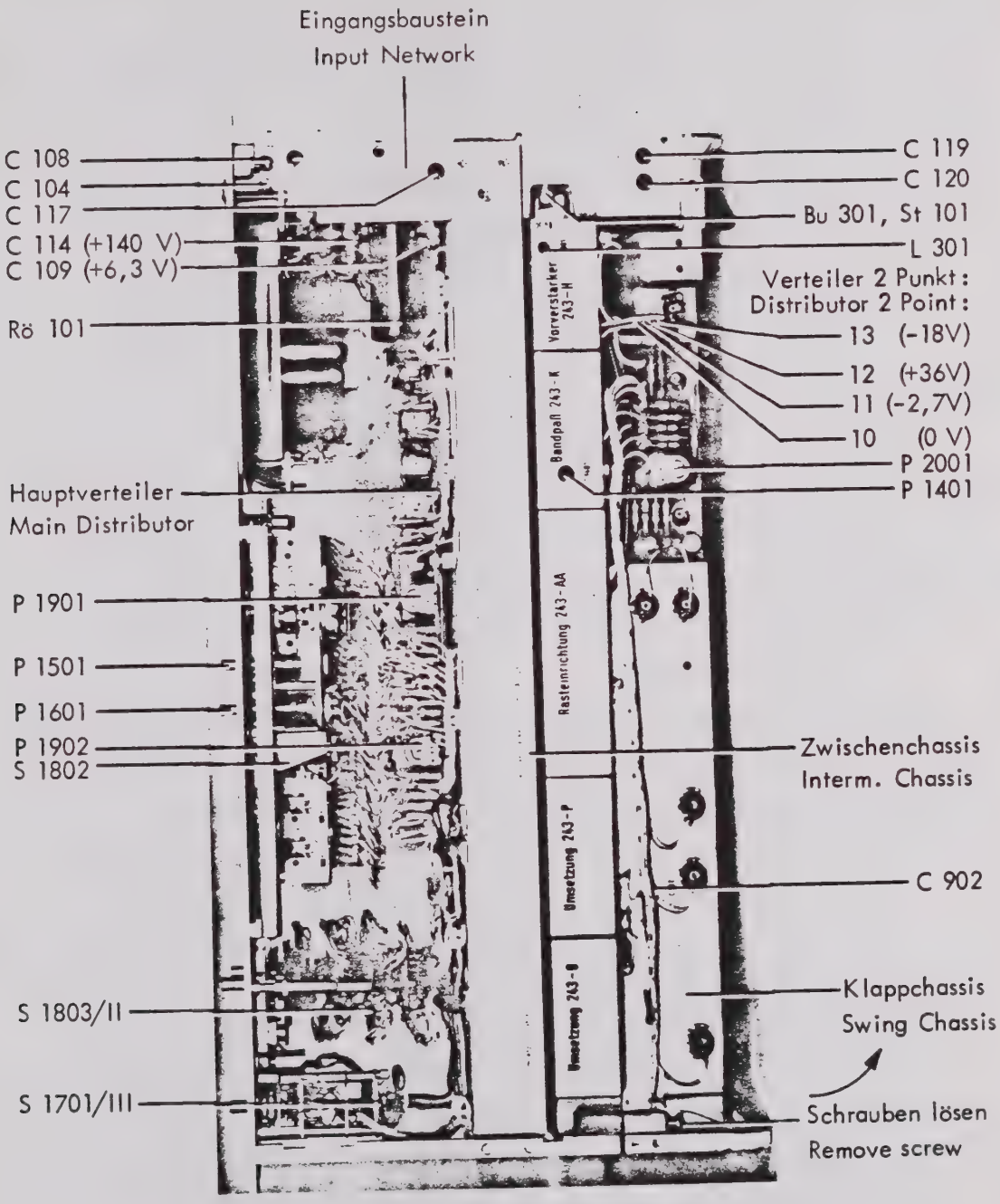



Bild 37 PM-5 Ansicht von oben
Fig. 37 PM-5 Top View

## 4.3.1. Operating Voltages

Switch on unit and select the linear calibration mode.

Measure the voltages at the following points with a DC voltmeter against the chassis of the RWO-5:

Distributor 2, printed circuit board 243-BB

| | |
|---|---|
| Point 10 black | ≈0 V (ground point, -30 mV) |
| Point 11 yellow | - 2.9 V (at 500 Hz bandwidth) |
| Point 12 red | + 36 V |
| Point 13 white | - 18 V |

Input unit, feed-through capacitor

| | |
|---|---|
| at C 109 | + 6.3 V |
| at C 114 | ≈140 V |

## 4.3.2. Test Points for the Rapid Localization of Faults

### 4.3.2.1. Examination of the Levels

A successful receiver fault finding method can be carried out by injecting a signal of the correct magnitude and frequency in the vicinity of the receive level meter. The injection point is then progressively advanced in the direction of the input until the correct indication is no longer achieved, thus localizing the faulty sub-unit. Generator levels up to ≈0 dB in the frequency range of 30 kHz to 69 MHz are necessary for this measurement of the PM-5. The frequencies must be accurately and finely adjustable because the receiver bandwidth has a maximum of ± 1.75 kHz (necessary levels and frequencies on page 117).

The following method is made in the opposite direction, that is a signal is fed to the receiver input and the appearing signal is followed through the receiver until it disappears and thus also indicating the defective sub-unit. The most favourable method is to make a selective measurement of the signal, but a wideband measurement is sufficient for a rapid examination.

The wideband method cannot be used when measuring at the input or output of mixers because the prevailing residual carrier is still superimposed on the signal frequency.

Because of this the test points were placed within the bandpass filters. Small test points have been provided for frequencies in the highest IF range of 69 MHz, because the possibility of spurious signal introduction is extremely great. A number of test points have been screened by a small metal cap for the same reason.

A list of the test points used in the wideband measurement is given on page 117. The measurement is made in the order given. The hinged chassis is now tilted out after loosening the two screws and the connection cable at the rear of the PM-5 placed between plug St 101 and socket Bu 301.

The given levels are valid for the linear calibration position and a deviation of 20 % is allowed.

Test points 2, 3, 8 and 9 are potentials isolated from ground and points 13, 14 and 15 indicate the locked condition of the carrier oscillators.

After the defective sub-unit has been found, a thorough examination can be made by checking the operating points against the values given in the circuit diagram, by measuring the gain and loss values according to the level chart, additionally testing the operation of the relays with the relay plan and viewing the signal waveforms by means of an oscilloscope etc.

The level chart on page 119 gives a list of the level values of the individual sub-units in the linear calibration position. These levels are, with the exception of the carrier level, selectively measured and the corresponding level meter connected via a high-impedance probe.

4.3.2.2. Checking the Frequency Locking

The internal carrier oscillators of the PM-5 are locked to each other and to a 10 kHz standard frequency spectrum of the RWO-5. This guarantees the high frequency accuracy and stability of the tuning and frequency tracking of generator and receiver.

The 61.56 MHz oscillator operates more than 270 kHz from its nominal frequency in its unlocked condition, so that no calibration signal will be present on tuning to 100 kHz. Furthermore, the generator output voltage will not be indicated in the receiver portion during operation as PSM-5.

On the other hand the tuning frequency will only be shifted about 4 kHz if the crystal oscillator is not synchronized. It is true that in this case the synchronization between PS-5 and PM-5 will not occur, but the calibration signal will be easily found by detuning the interpolation oscillator.

Test points 13, 14 and 15 represent an easy method of checking the frequency locking, because the control voltage is a direct measure of the phase difference between oscillator voltage and synchronizing voltage.

If a interference quantity is fed to the control device during locked conditions, it should be compensated for in the control device. In practice a disturbing DC voltage (ground potential) is high impedance fed to the test point (control voltage) by placing a resistor parallel to the DC voltmeter. If the oscillator is frequency locked, the voltage reading will remain constant, whereas the voltage will vary by approximately 2 Volt when unsynchronized.

If the control voltage is observed with an oscilloscope and the oscillator or synchronizing frequency varied, the various conditions during the synchronization can be observed : In an unsynchronized state, an AC voltage, caused by the changing phase position, results, whose frequency corresponds to the difference between the oscillator and synchronizing frequencies. The amplitude can be as great as the maximum voltage deviation of the phase comparator stage but will be attenuated at high frequencies by a low-pass filter in the control voltage channel, so that only the DC voltage component remains.

On reaching the hold range, the control voltage will jump to a constant value and then passes continuously to the limit of the pull-in range. The AC voltage will reappear as soon as an unsynchronization occurs.

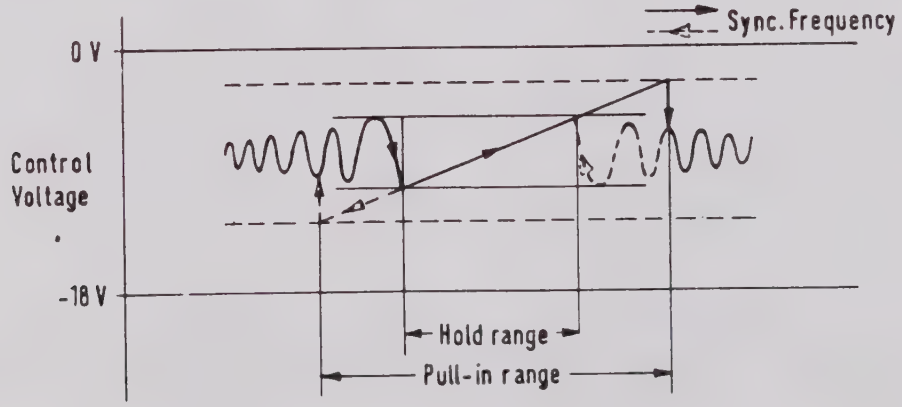



Fig. 38 Diagram of the control voltage on varying the frequency

The oscilloscope will display the following conditions:

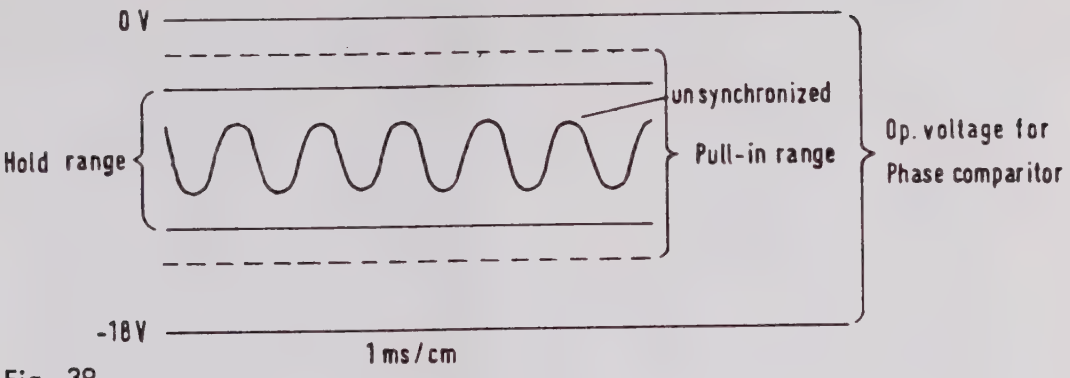



Fig. 39

The harmonic of the synchronizing frequency should be in centre of the hold range. The hold range can be measured by injecting an external synchronizing frequency, the exact frequency of which is indicated on a connected frequency counter. The oscillator frequency and hold range are then calculated by multiplication. The oscillator should be tuned so that the resulting frequency is symmetrical to the hold range. The control circuit should not oscillate within the hold range.
The control DC voltage should not possess any AC component.

Measurement values for the three carrier oscillators:

| No | Oscillator | $f_{sync}$/MHz | Synchronizing voltage $U_{pp}$/V | Injection point | Hold range | Oscillator alignment |
|---|---|---|---|---|---|---|
| 13 | 570 kHz | 1.0 | 2 | RWO-5 [1] Bu 1301 | ± 28.5 Hz | Ü 1203 |
| 14 | 6.84 MHz | 1.71 | 3 | 243-0, Pkt.5 [2] via 0.1 µF | ± 36 kHz | Ü 1103 |
| 15 | 61.56 MHz | 20.52 | 2.5 | 243-U, Pkt. 1 [2] | ± 270 kHz | C 902 |

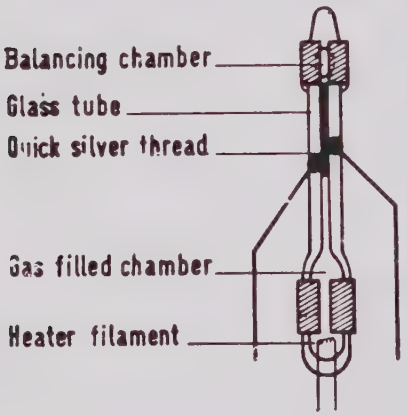
1) The output impedance of the generator must have a maximum galvanic connection of 100 kΩ to ground.

2) Remove connection to adjacent sub-unit.

The hold and pull-in range of the 570 kHz crystal oscillators are identical.
The Level Measuring Set PSM-5 allows an easy means of checking the frequency locking by feeding a signal from the PS-5 to the PM-5. If the PM-5 is in the bandwidth position "500 Hz", the same level should be indicated at generator and receiver.

## 4.3.3. Gas Pressure Relays [1]

Gas pressure relays are used to make all sensitivity variations; to switch to narrow bandwidth and logarithmic indication; and to select the demodulation mode. As shown in the adjacent diagramm these relays consist of a glass tube, containing a quick-silver thread. A gas-filled chamber with a heater filament is to be found at one end, which is used for energizing the relay. The filament heats the gas in the chamber, which expands and shifts the quick silver thread, thus making or breaking the galvanic connection. A metal bracket is provided so that a portion of the heat generated in the gas chamber is transferred to the balancing chamber at the opposite end of the tube, which ensures that the quick-silver thread will be returned as rapidly as possible, on removing the heater voltage.




Gas Pressure Relay

These relays operate very reliable and at short switching times if the heater voltage range is maintained. Due to the different loading of the voltage source, the voltage loss on the lead, filtering, switch contacts and maybe a blocking diode, values between 2.1 and 2.8 V are possible.
The quick-silver thread could be divided during extreme vibration and shock conditions, which would lead to a malfunction of the relay.

The relay plan on page 121 simplifies the location of the defective relay. Often two relays are used to form a changeover contact (one make and one break). The malfunctioning relay can be easily found with the aid of an ohmmeter, whereby it may be necessary to remove, for instance, a parallel transformer winding.
All gas pressure relays possessing a switching time greater than 1 second or who are not operating correctly must be replaced. Firstly, however, it is necessary to establish whether the correct heater voltage is available (DC voltmeter).
The operating check of the gas pressure relays must be made for the various modes. Receive frequency for instance 100 kHz.
Sections 4.3.3.1 to 4.3.3.5 indicate in which mode the relative relays can be checked.

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[1] Commencing with series I, the gas-pressure relays in the 30 kHz IF ( Rel 1401 to 1404, 1501 to 1508, 1601 to 1603 and 1701 to 1703 ) have been replaced by KACO relays.

4.3.3.1. Sensitivity Selection

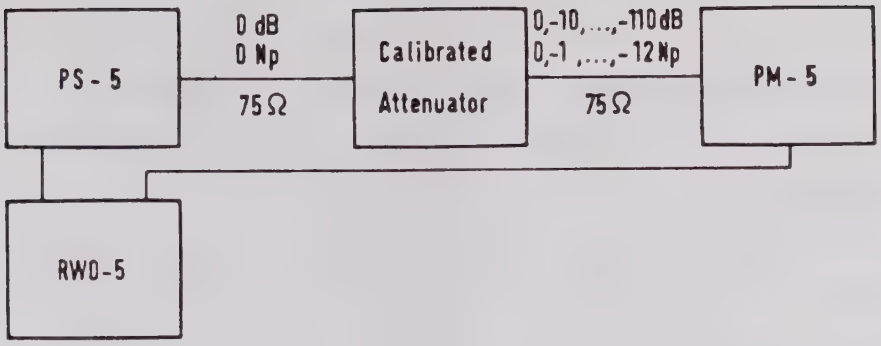



Fig. 40

The level values are adjusted with the attenuator and all sensitivity positions "LOW NOISE" and "LOW DISTORTION" must be checked both in the linear and logarithmic mode.

4.3.3.2. Linear and Logarithmic Calibration

Tune RWO-5 to 100 kHz. Relay Rel 112 will be energized by depressing the calibration button.

4.3.3.3. Bandwidth

Select linear calibration position; lock coarse frequency oscillator to 100 kHz; sweep width selector to position "0...100 kHz"; measure the 3 dB (0.35 Np) bandwidth by tuning the interpolation oscillator and observing the PM-5 meter.

Nominal values: broad f = ± 1.75 kHz

narrow = ± 250 Hz

The relay voltage is fed via distributor II (243-BB) point 11.

4.3.3.4. Demodulation Modes

Check the converter frequencies with a Frequency Counter FZ-1 connected via a 0.5 µF capacitor to either S 1701/III or 243-A point 1.

| Demodulator S 1701 | Bandwidth S 1801/6 | Frequency f/kHz |
|---|---|---|
| | broad | 28 |
| | narrow | 29 |
| | narrow | 31 |
| | broad | 32 |

4.3 3.5. Power Level

Feed a constant level at any desired frequency to the PM-5 input. Adjust $R_e = 1/\omega C_e$ for a 0 dB (0 Np) reading on meter J 1901 in position "VOLTAGE LEVEL"

Switch to "POWER LEVEL" and rotate the Z selector S 101. The meter should indicate the following values:

| Z / Ω | Indication | |
|---|---|---|
| | dB model dB | Np model Np |
| 50 | + 0,8 | - 0.06 |
| 60 | 0 | - 0.151 |
| 65 | - 0.35 | - 0.191 |
| 75 | - 0.97 | - 0.263 |
| 135 | - 3.52 | - 0.558 |
| 150 | - 3.98 | - 0.609 |

The following check can be made on the Level Measuring Set PSM-5:

Feed a level of 0 dB (0 Np) at 100 kHz from the PS-5 to the calibrated PM-5. Switch both units to power level. Vary the Z values at both units and adjust the PS-5 at each step to a reading of 0 dB (0 Np). The correctly terminated PM-5 must also indicate a reading of 0 dB (0 Np).

The characteristic impedance of the cable will not produce any voltage transformation at 100 kHz.

4.3.4. Mixer I Carrier Balance

If the mixer is unbalanced, the residual carrier could cause an overloading of the subsequent stage so that the signal is incorrectly indicated. The intrinsic noise of the receiver will increase at low frequencies under poor carrier balance conditions.

Alignment of the carrier balance:

Switch PM-5 to logarithmic calibration and select zero frequency at the RWO-5 (maximum reading at the PM-5).

The trimmer screws of C 508 and C 510 should be 2 mm under the cover. That trimmer should now be adjusted, which decreases the reading on rotating in a clockwise direction. This trimmer is now adjusted alternately with P 2001 for a minimum reading. Nominal value $\leqq$ - 25 dB (-2.3 Np) with a calibrated PM-5.

## 4.3.5. Frequency Response

### 4.3.5.1. Z = 75 Ω

The basic frequency response of the PM-5 is compensated for in the pre-amplifier by a frequency dependent negative feedback.

The frequency response of various pre-attenuator positions can be coincided with another For the frequency response alignment, the difference between the input and output voltage is observed. The input voltage is fed via a 75 Ω resistor to the receiver input, in order to ensure that the 75 Ω input impedance of the PM-5 is also taken into consideration. The generator voltage is measured with an RF voltmeter possessing a DC output. The level of the PS-5 should not be in advance of ≈ -10 dB, so that a low distortion factor is maintained (< 1 %). If the Sweep Measuring Set WM-50 is available, the frequency response curves can be displayed.

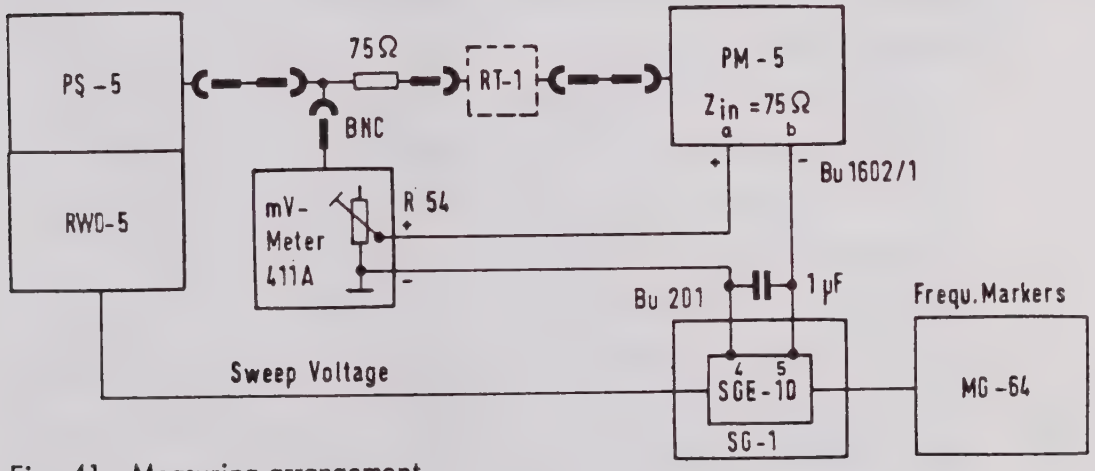



Fig. 41 Measuring arrangement

Generator portion PS-5: Select 0 dB (0 Np) $Z_{out}$ = 75 Ω, output level ≈ -10 dB (-1.15 Np), ie. ≈310 mV reading. Connect PS-5 via a 75 Ω standard resistor, without RT-1, to the PM-5. The reflection coefficient (r) of the resistor should be less than 0.005 at 36 MHz.

The measuring point for the millivolt meter must be directly adjacent to the resistor. The most favourable form would be a T-piece with built-in resistor and suitable connections.

Receive portion PM-5: $Z_{in}$ = 75 Ω, level control to -10 dB (-2 Np), linear and low noise modes, set calibration adjustment for meter f.s.d.

Oscillator portion RWO-5: Centre frequency 18.5 MHz, sweep width ± 17.5 MHz, sweep frequency 0.2 Hz. Display unit: Feed the difference between the input DC voltage at R 54 and the output DC voltage at socket 1602/1 to the Y input socket of the SGE-10 (socket Bu 201 contacts 4 and 5).

The external 1 µF capacitor acorss socket Bu 201 serves to suppress hum voltages.

The input and output DC voltage are now brought into coincidence with the aid of R 54, so that the frequency response curve and the fly-back trace of each are identical.

The X deflection is made by the sweep voltage obtained from the RWO-5.

Place the Y expansion range to "x 10" and adjust the Y amplitude with P 204 so that a 1 cm deflection corresponds to a 1 % variation of amplification. The calibration by parallel-connecting 1 MΩ to the DC voltage output with an output impedance of 10 kΩ, results in a virtual increase in attenuation of 1 %.

The frequency scale from 1 to 36 MHz can be checked by providing frequency markers at 9 MHz intervals.

A variable Attenuator RT-1 should be placed before the PM-5 when measuring the more sensitive positions of -20 dB to -50 dB (-3 Np to -6 Np), so that the reading on the millivolt meter remains unchanged. The characteristic impedance of the interconnection cable and the RT-1 must be 75 Ω and be equipped with 2.5/6 mm connectors. In the positions 0 dB (-1 Np) and+10 dB (0 Np), the attenuation of the post-attenuator can be reduced by 20 dB (2 Np), on placing the relay voltage of -2.7 volt at contact 1 of switch S 1803/II, see Fig. 37. This ensures that the level obtained from the PS-5 is sufficient. Since the attenuation of the pre-attenuator is identical for the sensitivity positions +20 dB (+1 Np or +2 Np) and -10 dB (-2 Np) low distortion, the frequency response measurement can be made without RT-1 at a generator output level of -10 dB(- 2 Np)

Order of alignment:

| Attenuator position | | Note | Alignment |
|---|---|---|---|
| 0 dB | -1 Np | RT-1 -2.7 V | L 301 as flat as possible |
| -50 dB | -6 Np | RT-1 | C 117 |
| -40 dB | -5 Np | RT-1 | Check |
| -30 dB | -4 Np | RT-1 | C 119 |
| -20 dB | -3 Np | RT-1 | C 120 |
| -10 dB | -2 Np | | Check (C 117) |
| +10 dB | 0 Np | -2.7 V | Check (C 119) |
| +20 dB | +1 Np | -10 dB (-2 Np) low distortion | Check (C 120) |

The frequency response can only be made in a point-for-point manner if the level meter does not possess a DC output. The input level must be adjusted for a constant reading at each measuring position.

The frequency response can also be checked, with a lower degree of accuracy, by directly connecting the generator output and receiver input.

The stabilized generator output supplies good results, especially at low frequencies, where the built-in characteristic impedances are still real, and this method can be used for check purposes over the whole frequency range.

The error consists of the frequency response error of the generator level (frequency response of the DC control voltage) and the dividing error between $Z_{out}$ of the PS-5 and $Z_{in}$ of the PM-5.

4.3.5.2. Z = 50, 60, 65, 135 and 150 Ω

The frequency response of the receiver portion has been optimumly aligned for an impedance of 75 Ω. The dividing error between $R_N$ and $Z_{in}$ has been taken into consideration by feeding via a 75 Ω standard resistor.

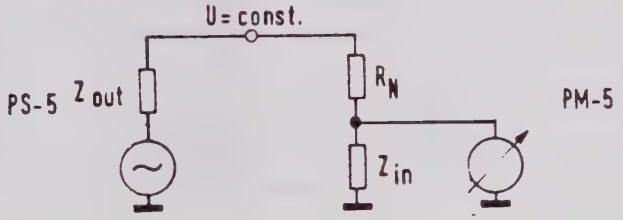



Fig. 42

Frequency response for impedances of 50 Ω, 60 Ω and 65 Ω:

These impedance values are obtained by placing additional resistor values in parallel. The reflection coefficient varies only slightly from the 75 Ω position and the characteristic impedance curve is similar.

The frequency response is therefore hardly effected and is a maximum of 1 % better or worse up to 15 MHz and 2 % better or worse up to 36 MHz.

Frequency response for impedances 135 Ω and 150 Ω:

The input capacity is neutralized in position $Z_{in}$ = 150 Ω. $Z_{in}$ = 135 Ω is also formed by parallel resistor switching. The reflection factor and the transfer locus of the characteristic impedance are virtually identical for both impedance values. The frequency response error possesses, in the most unfavourable condition, the sum of the two reflection coefficients for 75 Ω and 150 Ω. The maximum frequency response error for $Z_{in}$ = 75 Ω is less than 2 % up to 15 MHz.

According to Fig. 55, the reflection factor for $Z_{in}$ = 75 Ω up to 15 MHz amounts to less than 1 % and for $Z_{in}$ = 150 Ω approximately 5 %. If all errors are additing, the frequency response can deviate by 8 %.

4.3.5.3. High Impedance Input "$R_e = 1/\omega C_e$" ($Z_{in} = 1/\omega C_{in}$)

The test object will be loaded with the input capacity $C_{in} \approx 30$ pF and possibly the capacity of the connection cable on making measurement without a terminating resistor. If the test object is terminated, the input capacity $C_{in}$ will not be neutralized as would be the case if the terminating resistor of the receiver portion were used. The capacitive reactance $1/\omega C_{in}$ amounts to approximately 150 Ω at 36 MHz.

The Probe TK-8 is operated in the "$1/\omega C_e$" position. The output impedance is low and the frequency response is aligned to the high impedance input of the receiver.

4.3.6. Attenuation Values

4.3.6.1. Attenuation of Distortion

A distortion-free signal is necessary to check the distortion attenuation of the wide-band portion of the PM-5. The harmonics of the input signal must therefore be suppressed with a low-pass or harmonic filter.

The measurement of the second and third harmonics $H_2$ and $H_3$ is carried out in the low distortion position. The input impedance amounts to $Z_{in}$ = 75 Ω and the input signal to -40 dB (-5 Np). The sensitivity should be increased by 50 dB (6 Np).

Nominal value of the harmonic distortion attenuation (a) is a $\geqq$ 70 dB (8 Np).

Input signals of 23 MHz and 34.5 MHz possess harmonics at 69 MHz and supply the distortion values of mixer I, whereby the 36 MHz low-pass filter, with its attenuation peak at 69 MHz, operates as a harmonic filter.

The characteristics of the unit can under certain conditions be considerably better than the guaranteed specifications. To indicate the distortion product, the sensitivity of the level meter is switched down one position and the meter reading observed. The harmonic distortion factor of the input signal can now be measured if the reduction of the reading was linear. An intrinsic distortion of the receiver is indicated if a non linear variation has been observed.

4.3.6.2. IF Suppression

The attenuation of the 1. IF of 69 MHz is essentially determined by the 69 MHz attenuation peak of the 39 MHz low-pass filter. See 5.3.6. for details regarding measurement and alignment of C 406.

Nominal value for all tuning frequencies a ≧ 70 dB (8 Np).

4.3.6.3. Image Rejection

The image rejection for mixer I can be measured as described in 5.3.6. for input frequencies between 138 and 174 MHz, corresponding to a tuning frequency of 0 to 36 MHz.

Nominal value: a ≧ 70 dB (8 Np)

The image rejection values for the other mixers are greater than this. The input signal of 0 dB is supplied from a Signal Generator MG-64 and the receive level then directly corresponds to the image rejection.

Nominal value: a ≧ 80 dB (9 Np)

| Input frequency | Tuning frequency | Mixer |
|---|---|---|
| 160 kHz | 100 kHz | IV |
| 2.2 MHz | 1 MHz | III |
| 18.88 MHz | 4 MHz | II |

4.3.7. Disturbing Signals

4.3.7.1. Intrinsic Noise

The intrinsic noise of the receiver is constant at tuning frequencies above 1 MHz. The noise level increases at lower frequencies. The values are dependent on the carrier balance of the mixers and on the noise charqcteristics of the mixer diodes GI 501 to GI 504. The noise level in the 500 Hz bandwidth position is 9 dB (1 Np) lower than in the 3.5 kHz position.

The measurement is carried out with a calibrated PM-5 in its most sensitive position of -110 dB (-12 Np); the input socket open; input impedance $Z_{in}$ = 75 Ω and 3.5 kHz bandwidth.

Nominal value: Tuning frequency 80 kHz — Meter reading ≦ -11 dB (-1.5 Np)

4.3.7.2. Interfering Voltages in the Absence of an Input Signal

A defective instrument can sometimes be tuned to an signal even in the absence of an input signal. These interfering signals originate, for instance, in the power supply or from an oscillator, which, due to the ineffective filtering, induces unwanted signals into the input circuitry.

If the harmonics of the RWO-5 control signal carrier I are passed through mixer I and the 69 MHz band-pass filter, mixer II could generated the IF of 7.44 MHz from a harmonic of carrier II. The band-pass must have a sufficient degree of attenuation up to approximately 500 MHz.

| Example: | | |
|---|---|---|
| | Tuning frequency | 6.09 MHz |
| | | +69.00 MHz |
| | Carrier I | 75.09 MHz |
| | 4 x Carrier I | 300.36 MHz |
| | Carrier II | 61.56 MHz |
| | 5 x Carrier II | 307.80 MHz |
| | 5 x Carrier II - 4 x Carrier I | 7.44 MHz |

The control frequency of the RWO-5 is generated as the sum of two frequencies, firstly the coarse frequency oscillator signal and secondly that of the interpolation oscillator. When tuned to 3 MHz the coarse frequency oscillator operates at a frequency of 69 MHz. This signal could, thus in some unforeseen manner, be induced into the first IF of the PM-5, which is also at 69 MHz.

It is also possible that the PS-5 fixed frequency of 69 MHz, is induced into mixer I of the receiver portion. The spurious indication is, in this case, virtually independent of the tuning frequency and will disappear on switching off the PS-5. If the unit is vibrated, the microphonics of tubes may be observed as narrow band noise.

The following measurement is made in the most sensitive position -110 dB (-12 Np) of a calibrated PM-5; input impedance $Z_{in} = 75\ \Omega$; bandwidth 500 Hz.

The presence of interference signals originating from the power supply can be easily established by connecting a cable to the receiver input socket and placing the free end in the vicinity of the power supply.

List of possible interfering signals:

| Tuning frequency in kHz | Cause of interference |
|---|---|
| 10 | 10 kHz standard frequency |
| 10.5 | Tube microphonics |
| approx. 18 | Two point regulator frequency |
| approx. 28 | Chopper frequency |
| 80 | Noise ≦-121 dB (≦-13.5 Np) |
| approx. 56 | 2 x chopper frequency |
| 63.9 ± 2.5 kHz | Auxiliary oscillator frequency |
| approx. 84 | 3 x chopper frequency |
| 100 | 100 kHz standard frequency |
| approx. 112 | 4 x chopper frequency |
| approx. 128 | 2 x auxiliary oscillator frequency |
| approx. 192 | 3 x auxiliary oscillator frequency |
| 222.6 | 9 x carrier I - 10 x carrier II |
| 570 | 570 kHz oscillator frequency |
| 1000 | 1 MHz standard frequency |
| 1710 | 3 x 570 kHz oscillator frequency |
| 3000 } 6000 | Coarse or interpolation oscillator frequency |
| 6090 | 5 x carrier II - 4 x carrier I |
| 8880 | 8 x carrier I - 10 x carrier II |
| 11210 | 7 x carrier I - 9 x carrier II |
| 15560 | 3 x carrier I - 4 x carrier II |
| 19620 | 3 x carrier II - 2 x carrier I |
| 20560 | 3 x 6.84 MHz oscillator frequency |
| 27060 | 2 x carrier I - 3 x carrier II |
| 36080 | 3 x carrier I - 5 x carrier II |

A serviceable instrument should not indicate any spurious or interference signals in excess of 100 kHz.

The interference level in the range of 10 kHz to 30 kHz is below - 120 dB (-13.5 Np), and in the range 30 kHz to 1 MHz -125 dB (-14 Np).

4.3.7.3. Interfering Voltages on Sweeping with the Input Signal

A sideband of the RWO-5 control frequency could simulate the reception of a signal if the receiver is tuned to a frequency having an identical spacing from the carrier as the carrier-sideband spacing. A sideband of a internal PM-5 carrier could also cause an incorrect measurement. If the input signal has a frequency of 2.5 MHz and if the sideband is caused by the 28 kHz chopper frequency, a reading will be obtained on tuning to 2.528 MHz or 2.472 MHz.

The pass-band curve of the receiver is found by sweeping a fixed frequency. This curve diminishes outside the pass-band and disappears below the noise level. A second "pass-band curve" can be caused by a sideband, which will not be observed with a serviceable instrument. The sidebands can originate from the 10 kHz, 100 kHz or 1 MHz standard frequencies or from the chopper frequency of 28 kHz or harmonics thereof.

The following oscillogram was obtained on a display unit with the Sweep Measuring Set WM-50 at a sweep width of ± 35 kHz; the MG-64 at 2.5 MHz; the PM-5 in log. position and at a bandwidth of 3.5 kHz.

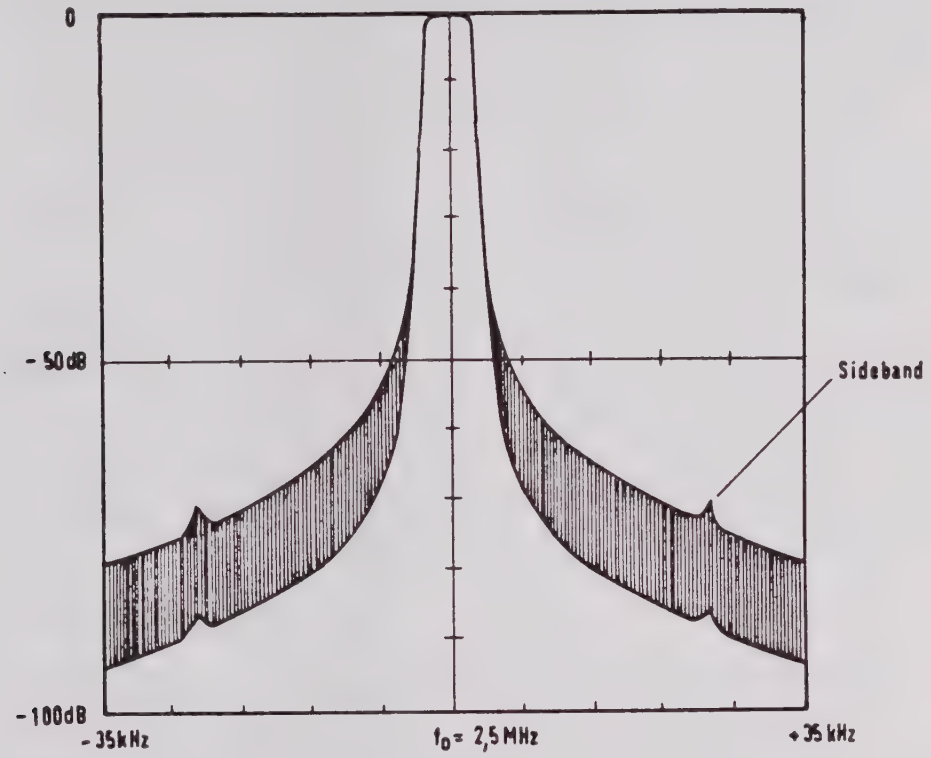



Fig. 43

AC line interference can be avoided by battery operation. The power transformer in the RWO-5 is mounted on felt supports to keep vibrations at a minimum. Such vibrations could cause an unwanted deviation of the interpolation oscillator and care should also be taken when other equipment is to be operated on the same table etc. In the Measuring Set PSM-5, however, the generator and tuning frequency will vary synchronously.

### 4.3.8. Transfer Impedance

The ground connection between generator and test object must be low-impedance when making measurements on high loss test objects. This is to ensure that the whole generator current flows back via this link. The ground of the PM-5 is isolated, in respect to the measuring frequencies, from the grounds of the RWO-5 and PS-5, and also from the cabinet.

Due to the electrical and mechanical assembly, a certain amount of coupling exists between the various grounds.

The transfer impedance $Z_{tr}$ can be measured, with the aid of the Probe TK-8, with the PSM-5 itself.

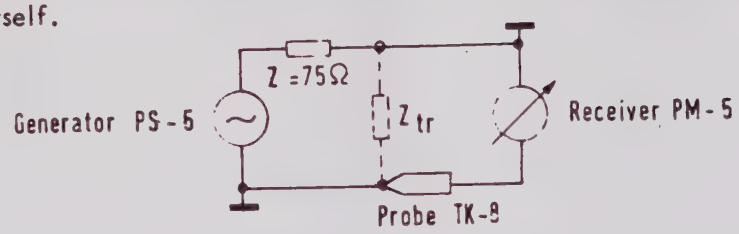



Fig. 44

Set the generator to a -6 dB (-0.7 Np) level reading and feed this to the ground of the PM-5. The voltage drop across $Z_{tr}$ is now measured. 0 dB (0 Np) will result at a $Z_{tr} = \infty$ , -6 dB (0.7 Np) at a $Z_{tr} = 75\ \Omega$ and -20 dB (-2.3 Np) at a $Z_{tr} \approx 8.3\ \Omega$. Fig. 45 shows the receive level as a function of the receive frequency. The curve remains above the minimum level given and does not exhibit any sudden dips.

The transfer impedance is dependent on:

a) The capacity between the chassis of the PM-5 to the RWO-5 and PS-5.

b) The filter chokes in the power supply of the PM-5.

c) The RC link between the ground of the PM-5 and RWO-5, which serves to suppress any resonance of the filter chokes.

d) The chokes with RC link in the control voltage supply.

e) The stray capacity of the synchronizing voltage transformer Ü 1301.

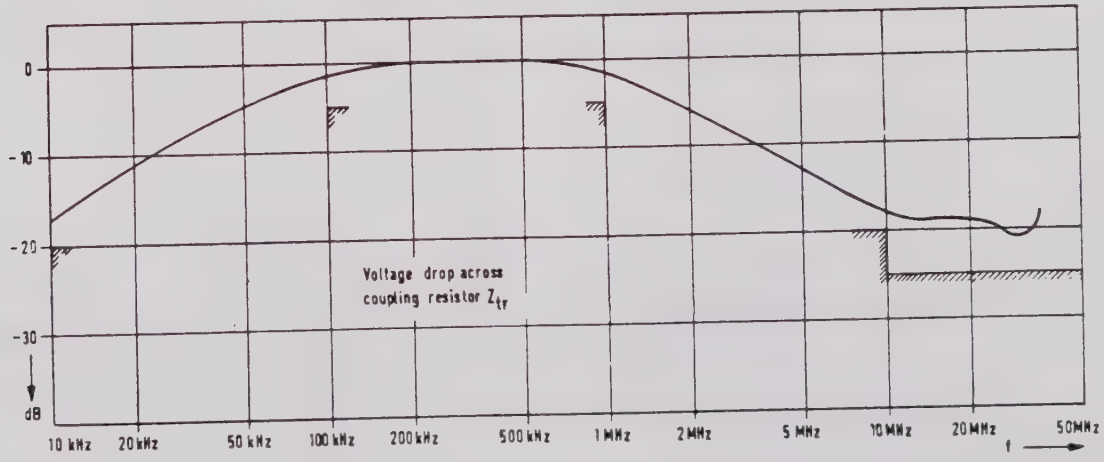



Fig. 45

Test points

PM-5 to "CAL" linear; calibration control to 0 dB (0 Np); RWO-5 to 100 kHz.

Necessary measuring equipment: DC voltmeter 100 kΩ/V (Gossen)

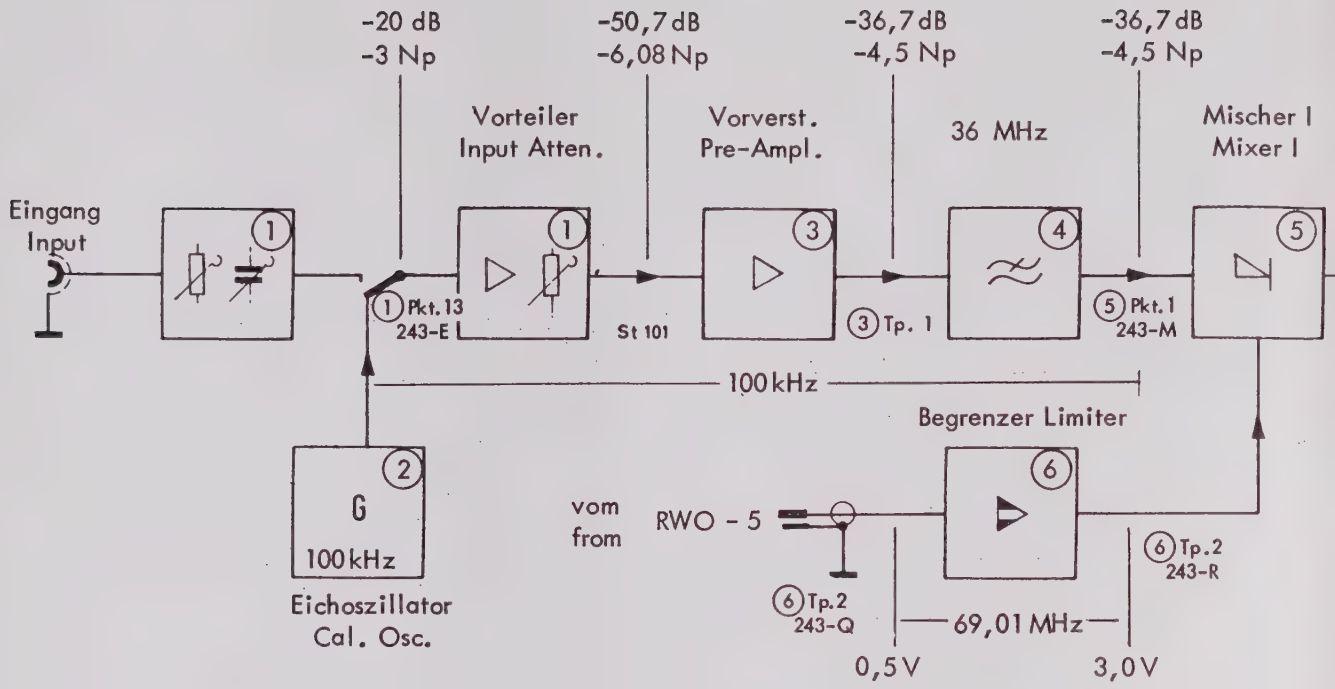
Wideband voltmeter SM-1 with probe TK-1 (W u.G)

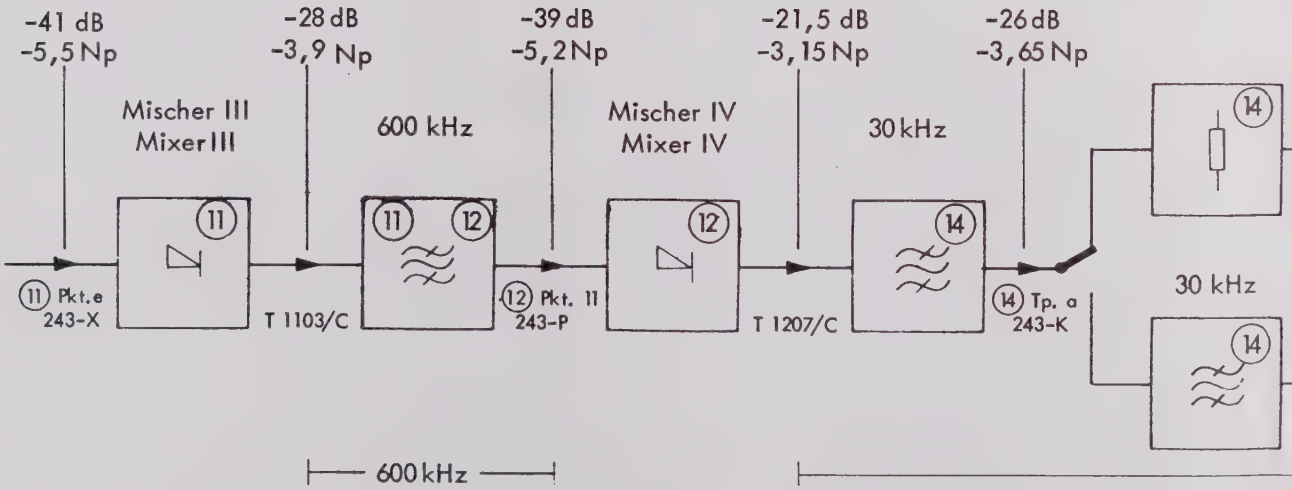
RF millivoltmeter type 411 A (hp)

All voltages are measured against ground

| No. | Test point | Frequency f/MHz | Measuring equipment | Voltage at the test points dB version | Np version | Notes |
|---|---|---|---|---|---|---|
| 1 | 243-E Tp.4 | 0.10 | SM-1 | -20 dB | -3 Np | |
| 2 | 243-E Tp.7 | 0.10 | SM-1 | -50.7 dB | -6.08 Np | 1) 2) |
| 3 | 243-H Tp.1 | 0.10 | SM-1 | -36 dB | -4.5 Np | 1) 2) |
| 4 | 243-Q Tp.2 | 69.10 | 411 A | ≈0.50 V | 0.50 V | 2) |
| 5 | 243-R Tp.2 | 69.10 | 411 A | ≈3.0 V | 3.0 V | 2) |
| 6 | 243-W Tp.a | 7.44 | 411 A | 52 mV | 58 mV | 2) |
| 7 | 243-Z Tp.a | 0.60 | SM-1 | -26 dB | -3.75 Np | 2) |
| 8 | 243-K Tp.a | 0.03 | SM-1 | -25 dB | -3.6 Np | 1) |
| 9 | 243-C Tp.6 | 0.03 | SM-1 | -27 dB | -3.85 Np | 1) |
| 10 | 243-C Tp. C | 0.03 | SM-1 | -1.5 dB | -0.95 Np | Casing T 1502 |
| 11 | 243-D Tp. C | 0.03 | SM-1 | -12.6 dB | -1.45 Np | Casing T 1605 |
| 12 | Bu 1602/2 Tp. | 0.03 | SM-1 | 0 dB | 0 Np | between a and b |
| 13 | 243-AA Tp.5 | - | 100 kΩ/V | ≈ -9.5 V; Rp.=330 kΩ | | 2) 3) |
| 14 | 243-Y Tp.4 | - | 100 kΩ/V | ≈ -5.5 V; Rp.= 68 kΩ | | 3) |
| 15 | 243-V Tp.3 | - | 100 kΩ/V | ≈ -5.5 V; Rp.= 15 kΩ | | 3) |

1) Potential isolated from ground
2) Cover cut-out
3) The control voltage is measured at points 13, 14 and 15 after which resistor Rp is placed in parallel. The voltage should not change if the frequency is locked




Erläuterung (Beispiel):

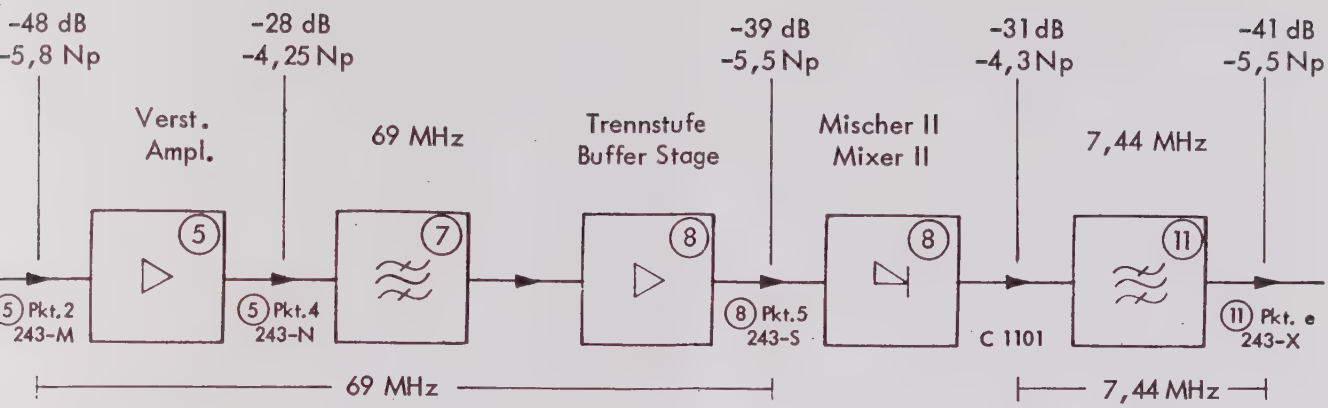
(14) = Stromlaufplan 14
243-M = Leiterplatte M
Pkt. 6 = Anschlußpunkt 6
Tp. a = Testpunkt a
T 1207/C Kollektor von T 1207

Note e.g. :

= circuit diagram 14
= circuit board M
= connect. point 6
= test point a
= collector of T 1207

Angegebene Pegel in S

Indicated levels apply
measured with respect



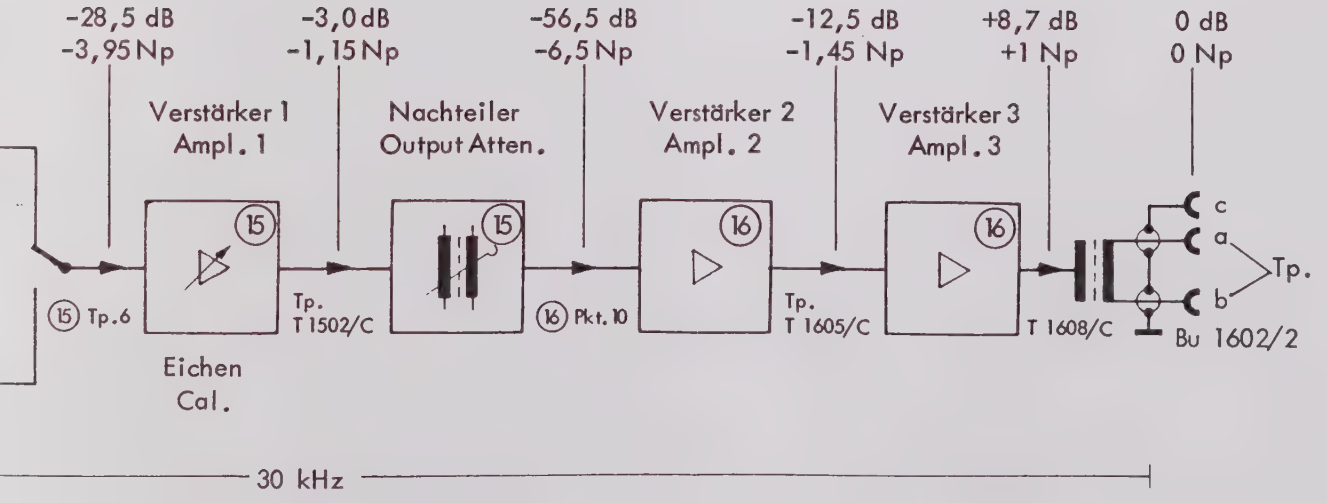




Bild (Fig.) 46 PM-5 / BN 243 und BN 243/1
Pegelplan dB, Np
(Signal Level Diagram)

ellung "Eichen lin" gegen Masse gemessen
o instrument in position "CAL. LIN." and
o ground.

| Relaisplan (Relay Diagram) | | | Nummern der erregten Relais (Operating Relay No.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| dB- und Np-Gerät (dB and Np version) | | | Vorteiler (input attenuator) | | | | | | | | Nachteiler (output atten | | |
| Tastensatz S 1801 (push-button-set) | S 1803 | | rt | gn | gn | rt | rt | rt | gn | rt | | | |
| | dB | Np | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 1509 | 1510 | 1511 |
| Messen lin. (measure lin.) | -110 | -12 | x<br>o | x<br>o | x<br>o | | x<br>o | | x<br>o | | x<br>o | x<br>o | x<br>o |
| | -100 | -11 | x<br>o | x<br>o | x<br>o | | x | | x<br>o | o | x<br>o | x<br>o | o |
| obere Zeile: x "rauscharm" | -90 | -10 | x<br>o | x<br>o | x<br>o | o | x | | x<br>o | | o | o | x<br>o |
| | -80 | -9 | x<br>o | x<br>o | x<br>o | | x | | x | | o | o | o |
| untere Zeile: o "klirrarm" | -70 | -8 | x | x | x | | x<br>o | | x<br>o | | x<br>o | x<br>o | x<br>o |
| | -60 | -7 | x | x | x | | x | | x<br>o | o | x<br>o | x<br>o | o |
| (upper line: x "low noise") | -50 | -6 | x | x | x | o | x | | x<br>o | | o | o | x<br>o |
| | -40 | -5 | x | x | x | | | | x | x | o | o | x<br>o |
| (lower line: o "low distortion") | -30 | -4 | x | x | x | x | | | x | | o | o | x |
| | -20 | 3 | x | x | x | | | | | | | | x<br>o |
| | -10 | -2 | | | | | x | | x | | | | x |
| | 0 | -1 | | | | | | | x | x | o | o | x<br>o |
| | +10 | 0 | | | | x | | | x | | o | o | x |
| | +20 | +1 | | | | | | | | | | | x<br>o |
| | - | +2 | | | | | | | | | | | |
| Messen log. (measure log.) | - | +2 | | | | x | | | x | | x | | |
| | +20 | +1 | | | | | | | x | x | x | | |
| Kein Unterschied zwischen "rauscharm" und "klirrarm" (no difference between "low noise" and "low distortion") | +10 | 0 | | | | | x | | x | | x | | |
| | 0 | -1 | x | x | x | | | | | | x | | |
| | -10 | -2 | x | x | x | x | | | x | | x | | |
| | -20 | -3 | x | x | x | | | | x | x | x | | |
| | -30 | -4 | x | x | x | | x | | x | | x | | |
| Eich.(cal.) lin. | | | | | x | | | x | | | | | x |
| Eich.(cal.) log. | | | | | x | | | x | | | x | | |

| | | eingeschaltete Dämpfung (insertion loss) | | | | | |
|---|---|---|---|---|---|---|---|
| ator) | log. | Vorteiler (input atten.) | | Nachteiler (output atten.) | | gesamt (total) | |
| 1512 | 1605<br>1606 | dB | Np | dB | Np | dB | Np |
| x<br>o | | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- |
| x<br>o | | -<br>10 | -<br>1 | 10<br>- | 1<br>- | 10 | 1 |
| x<br>o | | -<br>20 | -<br>2 | 20<br>- | 2<br>- | 20 | 2 |
| x<br>o | | -<br>30 | -<br>3 | 30<br>- | 3<br>- | 30 | 3 |
| o | | -<br>40 | -<br>4 | 40<br>- | 4<br>- | 40 | 4 |
| o | | -<br>50 | -<br>5 | 50<br>- | 5<br>- | 50 | 5 |
| o | | -<br>60 | -<br>6 | 60<br>- | 6<br>- | 60 | 6 |
| o | | 10<br>70 | 1<br>7 | 60<br>- | 6<br>- | 70 | 7 |
| o | | 20<br>70 | 2<br>7 | 60<br>10 | 6<br>1 | 80 | 8 |
| o | | 30<br>70 | 3<br>7 | 60<br>20 | 6<br>2 | 90 | 9 |
| o | | 40<br>70 | 4<br>7 | 60<br>30 | 6<br>3 | 100 | 10 |
| | | 50<br>70 | 5<br>7 | 60<br>40 | 6<br>4 | 110 | 11 |
| | | 60<br>70 | 6<br>7 | 60<br>50 | 6<br>5 | 120 | 12 |
| | | 70<br>70 | 7<br>7 | 60<br>60 | 6<br>6 | 130 | 13 |
| | | | 7<br>7 | | 7<br>7 | | 14 |
| | x | | 6 | | | | |
| | x | 50 | 5 | | | | |
| | x | 40 | 4 | | | | |
| | x | 30 | 3 | | | | |
| | x | 20 | 2 | | | | |
| | x | 10 | 1 | | | | |
| | x | - | - | | | | |
| | | 30 | 3 | 60 | 6 | 90 | 9 |
| | x | 30 | 3 | | | | |

Bandbreite und Demodulationsart
(Bandwidth and mode of demodulation)

| Schalter- bzw. Tastenstellung (switch or push-button-position) | | Relaisnummer (relay No.) | | | |
|---|---|---|---|---|---|
| | | Umsetzoszillator (carrier oscillator) | | | b |
| S 1701 | S 1801/6 | 1704 | 1705 | 1706 | 1405, 1406 |
| | 3,5 kHz<br>500 Hz | x | x | | x |
| | 3,5 kHz<br>500 Hz | | | x | x |
| | 3,5 kHz<br>500 Hz | | | | x |

Bei Umschaltung auf Leistungspegel kommt Relais 1513 hinzu.

(Relay 1513 is also included in the power level mode).

---

x bzw. o = Relais erregt

x resp. o = relay operative

Die Arbeitsweise der Stabrelais ist durch Farbpunkte gekennzeichnet.

Es bedeutet :

rot (rt) = Arbeitskontakt

grün (gn) = Ruhekontakt

(The relay contacts are colour coded as follows :

red (rt) = normally open

green (gn) = normally closed)

---

Reed-Kontakte im Abschlußwiderstand
(reed switch for terminating impedance)

| S 101 | Widerstand und Relaisnummer (resistance and relay No ) | | | | | |
|---|---|---|---|---|---|---|
| Z/Ω | 150 Ω<br>101 | 300 Ω<br>102 | 487,5 Ω<br>103 | 75 Ω<br>104 | 1350 Ω<br>105 | 150 Ω<br>106 |
| 50 | x | | | x | | |
| 60 | | x | | x | | |
| 65 | | | x | x | | |
| 75 | | | | x | | |
| 135 | | | | | x | x |
| 150 | | | | | | x |

PM-5/BN 243, 243/1

Relaisplan (Relay Diagram)

# 5 CHECKING and ALIGNMENT

## 5.1. Oscillator Portion RWO-5

### 5.1.1. Instructions Regarding the Checking of the Power Supply

The transformer, switches and fuses are accessable on removing the unit from its cabinet. Therefore attention must be exercised to avoid electric shocks! !
Since the circuit board of the two point regulator 241-0 is mounted below the filter circuit board 241-R, it is necessary to release the latter by unscrewing and tilting it upwards.
The two chokes L 2405 and L 2406, the diodes GI 2402 and GI 2407, and the electrolytic filter capacitors C 2401 and C 2402 are accessable underneath the circuit board 241-0.

The connections of the power transformer are illustrated in section 5.1.1. "Mains Operation" of the Operating manual.

### 5.1.2. Power Supply

Check the insulation resistance between the casing of T 2401 or T 2402 and the power supply chassis of the non-operating unit with the aid of an ohmmeter.
Nominal value: ∞
This is to ensure that the two point regulator is "high" i.e. has no ground connection.
Checking the chopper:
Connect PS-5 and PM-5 as load for the power supply. Release circuit board 241-R by unscrewing and tilting upwards, thus making circuit board 241-0 accessable.
Disconnect the leads to the two point control at points 8 and 9 of circuit board 241-0 and feed the chopper from an external DC supply.
Set current limiting on the DC supply to 1 A.
Slowly increase the voltage at the power supply and observe whether the chopper commences oscillation.
A continuous tone should be heard during oscillation at input voltages from 4 V to approximately 8 V.

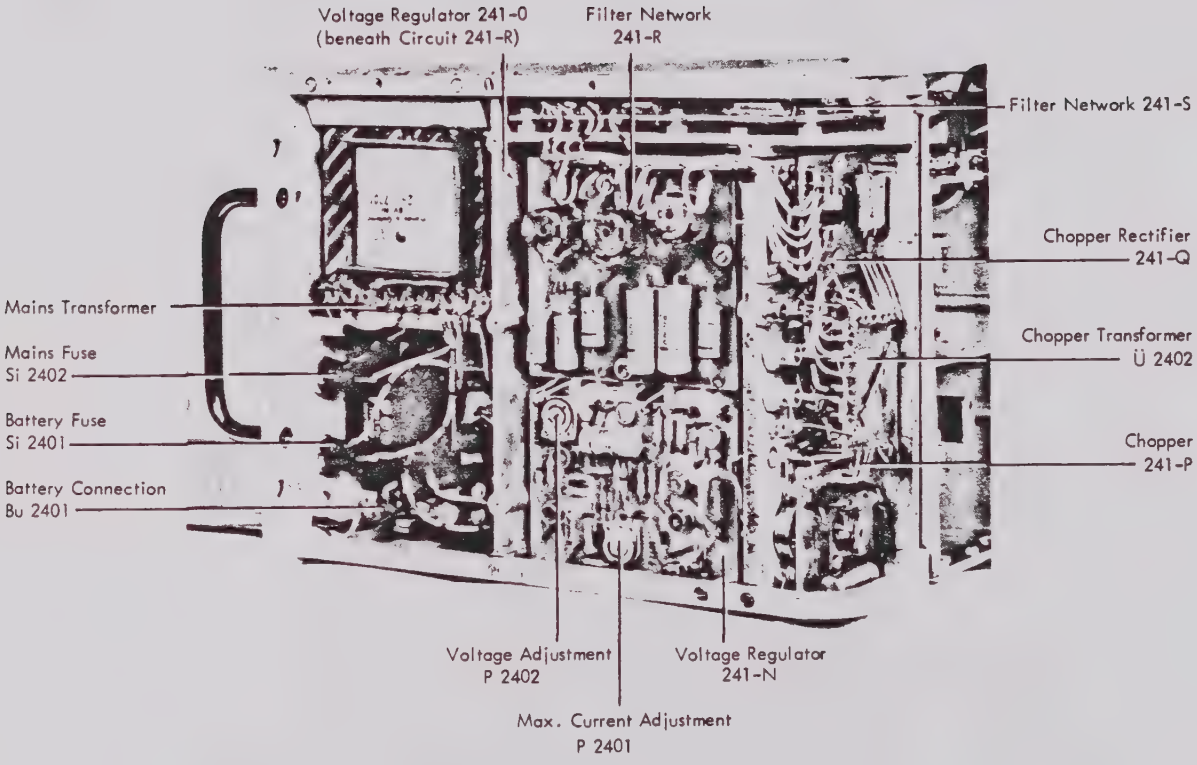



Fig. 47 PSM-5 Power Supply

Measure the voltage to ground at point e of the additional filtering circuit board 241-AX.

Place the current limiting of the DC supply to 6 A and increase the chopper input voltage until 6.3 V is measured at point e, or 6.5 V for instruments of series A, B and C.

The input current should now amount to 5 A and the input voltage to 17.3 V.

Measure the voltages at the other connections of circuit board 241-AX against ground.

| Point : | Nominal value: |
|---|---|
| c | + 180 V |
| d | + 37 V |
| f | - 2.9 V * (adjust with P 2501 of circuit board 241-AX) |
| g | - 19 V |

Measure the chopper frequency between point 5 and point 1 of the circuit board 241-P with a frequency counter.

Nominal value: 28 kHz

* For this alignment, the following adjustments are necessary at the PM-5:
Bandwidth to narrow, power level, demodulator position to
level switch to - 110 dB (- 12 Np).
The voltmeter should have an accuracy of better than ± 0,5 %.

## 5.1.3. Checking of the two point regulator

Reconnect the chopper (point 8 and 9 of circuit board 241-0).

Rotate the maximum current control P 2401 and the voltage control to their fully clockwise positions.

Connect an ammeter with a measuring range of at least 6.6 A f.s.d. parallel to C 2404.

Switch on unit and adjust the short circuit current to 6.5 A.

Switch off measuring set and remove ammeter.

Connect the PSM-5 via a current meter to the AC line 220 V (120 V) and switch on.

Adjust the voltage at point e of circuit board 241-AX to 6.3 V with potentiometer P 2402. Measure the AC line current.

Nominal value: 0.76 A (1.4 A)

Measure voltage to ground at the following points of circuit board 241-AX:

| Point: | Nominal value: |
|---|---|
| c | + 178 V |
| d | + 36.5 V |
| e | + 6.3 V |
| f | - 2.9 V |
| [illegible] | - 18.4 V |

## 5.1.4. Residual AC measurement

Screen the power supply and switch on the unit.

Measure the residual AC levels with an oscilloscope in position 5 mV/cm at the following points of circuit board 241-AX:

| Point: | DC voltage | Nominal value of residual AC peak-to-peak: |
|---|---|---|
| f | - 3 V | 8 mV (40 mV) * |
| e | + 6,3 V | 10 mV |
| d | + 36 V | 15 mV |
| c | + 180 V | 150 mV |
| a | 0 | 2 mV |
| g | - 18 V | 18 mV |

* 8 mV is the low-frequency and 40 mV the high-frequency component of the residual AC level.

## 5.1.5. Checking the 1 MHz Standard Frequency

The standard frequency should be checked after an operational period of one hour at an ambient temperature of 15 to 25° C.

The 1 MHz signal from socket Bu 1303 is fed to the vertical input of the oscilloscope and a 1 MHz reference frequency with a max. error of $\pm 1 \times 10^{-6}$ connected to the horizontal input, thus forming a Lissajous figure.

The trimmer capacitor C 1305 "CAL" is now adjusted to bring the distorted ellipse to a standstill.

The 1 MHz standard frequency at socket Bu 1303 should now show oscillogram 1 of Section 6.1.

### 5.1.6. Checking the Output Signals of the Standard Frequency Buffer

Connect an oscilloscope via a 10 : 1 probe to socket Bu 1102 of the buffer stage (11) (circuit board 241-AV).
Oscillogram 2 should be displayed.
Oscillogram 4 should be obtained at point 3.
Oscillogram 5 should be available at point 2.

### 5.1.7. Checking the Divided Frequencies

Connect an oscilloscope via a 10 : 1 probe to point 1 of the 2.7 MHz crystal oscillator (17) (circuit board 241-K). Oscillogram 6 should be displayed.
Measure at point 11 of the phase meter (14) (circuit board 241-AR).
Oscillogram 7 should be displayed.
Oscillogram 10 should be displayed at point 1 of the tuning indicator (19) (circuit board 241-AA) and oscillogram 3 observed at socket Bu 1101 of the standard frequency buffer stage (on circuit board 241-AW).

### 5.1.8. Checking the Frequency of the 2.7 MHz Oscillator

Disconnect the input of the mixer at point 3. Connect an oscilloscope via a 10 : 1 probe to point 2 of the frequency converter (20) .
Oscillogram 14 should be displayed.
Fed the 1 MHz standard frequency from socket Bu 1303 to the horizontal input of the oscilloscope. The displayed figure should be stationary.
Reconnect the mixer input at point 3.

### 5.1.9. Checking the Frequency of the Interpolation Oscillator, the 10 : 1 Frequency Divider and that of the Frequency Converter.

Set the interpolation oscillator to 100 kHz.
Place switch S 1602 to position 1.
Connect an oscilloscope via a 10 : 1 probe to point 4 of the buffer and switching stage (21) (circuit board 241-H).
Oscillogram 15 should be displayed.

Connect the oscilloscope to point 2 of the 400 kHz low-pass filter (20) (circuit board 241-D).

Oscillogram13 should be displayed.

Externally feed the time base of the frequency counter from socket Bu 1303 with the RWO-5 standard frequency. Connect the frequency counter input via a 10 nF isolating capacitor to point 4 of the buffer and switching stage (circuit board 241-H).

Tune interpolation oscillator for a 3100 kHz indication at the frequency counter.

Place switch S 1602 to position 2, after which the display should read 4000 kHz.

### 5.1.10. Checking the Carrier Level for the Frequency Converter

Tune coarse frequency oscillator to 36 MHz.

Measure the carrier level at point 2 of the frequency converter (3) (circuit board 241-Z) with a RF millivoltmeter. Nominal value : > 400 mV.

Tune coarse frequency oscillator to 0 MHz, checking at the same time the carrier level, which should increase to over 600 mV.

### 5.1.11. Operational Check of the Phasemeter

The examination of the pulse shaping stages can be made if the correct signals are available for the phasemeter at points 2 and 11 (see oscillograms 5 and 7 of Section 6.1.) and if the amplitude of the coarse frequency oscillator signal is at its nominal value of at least 400 mV.

Connect an oscilloscope via a 10 : 1 probe to the collector of T 1403. Oscillogram 8 should be displayed.

Oscillogram 9 should be available at the collector of T 1405.

Checking of the 1 MHz channel:

Connect the oscilloscope direct to point 5 of the phasemeter. Tune the coarse frequency oscillator to a locking point n x 1 MHz (n = 1,2 etc.). The difference frequency should continue to reduce during the tuning and the amplitude should increase to $U_{pp}$ = 400 mV.

The amplitude should return to about 8 mV on reaching the hold range. The 1 MHz frequency is then observed superimposed on to a DC voltage

Checking the 100 kHz channel :

The oscilloscope must be isolated from ground (eg. isolating transformer) during

measurement of the pull-in range. Select a vertical sensitivity of 100 $\frac{mV}{cm}$ and DC input.

Connect point 6 of the phasemeter to the oscilloscope ground connection and point 8 via a normal, unscreened measuring cable to the vertical input socket.

Lock the coarse frequency oscillator.

Tune slowly from the locked position and observe that the voltage displayed at the oscillograph will begin to increase. This voltage will return to 0 on leaving the pull-in range. The pull-in itself should occur at a voltage of at least 100 mV.

The pull-in voltage range should be symmetrical, ie. the range above and below the locked position should be virtually equal.

Nominal value: ± 100 mV.

### 5.1.12. Checking the Output Amplitude of the Auxiliary Oscillator

Tune coarse frequency oscillator to 0 MHz.

Connect an oscilloscope via a 10 : 1 probe to point 4 of the auxiliary oscillator discriminator (6) (circuit board 241-AD). Oscillogram 17 should be displayed.

### 5.1.13. Adjustment and Checking of the Control Frequency Amplitude

Remove the plug connection at the control frequency output. Connect the RF millivoltmeter to point 5 or 6 of the control frequency buffer. Adjust the amplitude to 1 V with P 101.

Tune the coarse frequency oscillator to 5 MHz.

The coarse frequency is now tuned through the range up to 36 MHz, during which the amplitude should not deteriorate by more than 50 mV from the value obtained at 5 MHz.

Note: The control frequency supply at socket Bu 104 should not be allowed to operate under non-signal conditions if the plug connections at the output of the control frequency buffer. This is because a non-load condition would, due to the transformation via L 103, cause a considerable loading of the control frequency buffer, which would result in a reduction of the control frequency amplitude.

## 5.1.14. Checking the Signal Level for Frequency Converter

Tune coarse frequency oscillator to 5 MHz.

Measure the voltage at point 1 of the frequency converter (3) (circuit board 241-AS).

Nominal value: 85 mV

## 5.1.15. Adjustment of the Discriminator Current and Alignment of the Linearization.

Check the voltage of the 15 V control circuit at point 2 of the linearization (7) (circuit board 241-AQ). Adjust if necessary with P 702. Remove the leads from points 5 and 6. Place a milliammeter (accuracy 0.5 %) between the removed lead and point 5 (positive termined to point 5).

Caution : Do not break the current loop during measurement, because this would cause T 707 to block, thus increasing the voltage at point 4 to over 20 V and destroying the capacity diodes in the control oscillator.

Place switch S 1602 to position 1.

Tune and lock the coarse frequency oscillator to 36 MHz.

Adjust the current flowing in the linearization to 1 mA with potentiometer P 601 in the auxiliary oscillator discriminator (6) .

Measure the voltage at point 4 of the linearization with a 100 kΩ/V voltmeter.

Nominal value: + 19 V (correct if necessary with P 701).

Tune and lock the coarse frequency oscillator to 11 MHz.

Measure the current flow.

Nominal value: 6 mA ± 0.2 mA (nominal value corresponds to a discriminator slope of 0.2 mA/MHz

Switch off, remove ammeter and reconnect lead to point 5.

Connect the frequency counter to point 10 of the frequency and phase control.

Switch on unit and lock coarse frequency oscillator to 36 MHz.

Counter should read 3 MHz ± 0.05 MHz.

The alignment flap of L 201 can, if necessary, be adjusted by placing a steel rod into the cut-outs provided on the alignment flap axle and rotating (see Fig. 50).

The control oscillator cover is slotted for this purpose and should not be removed.

Tune and lock the coarse frequency oscillator to 16 MHz.

Align the frequency indicated on the counter with linearizing potentiometer P 703 to 3 MHz ± 0.05 MHz.

Tune and lock the coarse frequency oscillator to 0 MHz.

Align the frequency indicated on the counter with linearizing potentiometer P 704 to 3 MHz ± 0.05 MHz.

Tune the coarse frequency oscillator from 0 MHz through to 36 MHz and observe the frequency indication. It should read 3 MHz ± 0.5 MHz throughout the whole range.

Reconnect lead to point 6.

### 5.1.16. Characteristic Curve Alignment of Counter Discriminator I

Remove the sweep current lead from point 4 (circuit board 241-AU) of the frequency and phase control (8).

Connect point 2 to point 7.

Place switch S 1602 to position 13.

Connect an oscilloscope direct to the connection point of R 801, R 802 and C 803 of the frequency and phase control.

Tune interpolation oscillator to 45 kHz and coarse frequency oscillator to 0 MHz.

Align the difference frequency to minimum with trimmer C 912 of counter discriminator I.

Place interpolation oscillator to scale marker -10, adjust through to scale marker 100 and measure the difference frequency.

Nominal value: ± 20 kHz.

Reconnect lead to point 4.

### 5.1.17. Checking the Frequency and Phase Control

Place switch S 1602 to position 1.

Connect the vertical input of the oscilloscope to point 9 and the horizontal input to point 10 of the frequency and phase control with unscreened measuring leads.

Switch the horizontal deflection to "ext".

Tune the coarse and interpolation oscillator throughout the whole range.

A sharp stationary, but strongly distorted ellipse should be displayed, whose position is slightly shifted on tuning the oscillators.

## 5.1.18. Checking of the Hold Range of the Phase Control

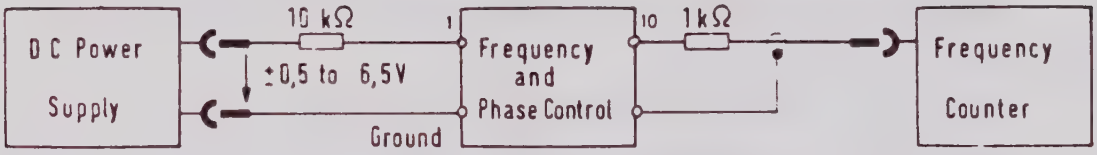



Fig. 48

An additional current is fed from a DC source via 10 kΩ and is impressed to point 1 of the frequency and phase control. This additional current causes a variation of the control frequency, and thus also a change of the output frequency of counter discriminator I. If the difference frequency at the input of the phase control (point 9 and point 10 of circuit board 241-AU) is greater than the pull-in range, then this indicates that the phase control is non-operative.

To check the hold range, tune the coarse frequency oscillator to 0 MHz and the interpolation oscillator to 0 kHz.

The frequency counter should now indicate 3000 kHz.

Impress a positive current until the counter indication jumps to a value 3000 kHz.

Observe the frequency counter whilst reducing the current flow.

The frequency by which the return jump to 3000 kHz is made, is the upper limit of the hold range.

Nominal value: > 100 kHz

The lower limit is correspondingly found by impressing a negative current.

Nominal value: > 100 kHz.

## 5.1.19. Checking the Output Amplitude of the Sawtooth Generator

Connect a DC oscilloscope via a 10 : 1 probe to contact 1 of socket Bu 1601 of the sawtooth generator.

Place switch S 1601 to position 10.

Oscillogram 18 should be displayed.

Switch S 1601 through to position 1, whereby the periodic duration must increase.

A DC voltage must be displayed in position 1, which should be adjustable with P 1601.

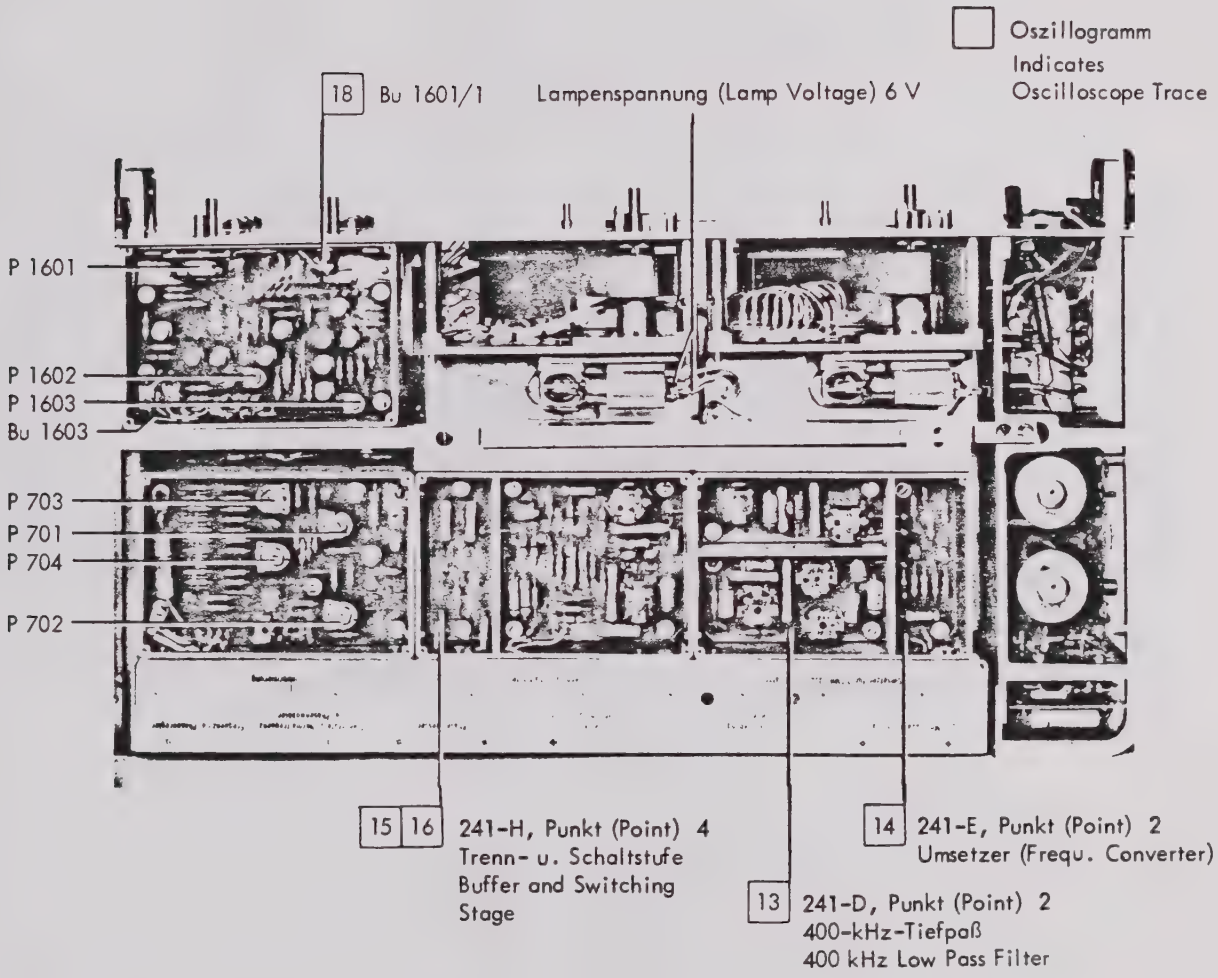



Bild 49 RWO-5 Ansicht von unten
Fig. 49 RWO-5 Bottom View

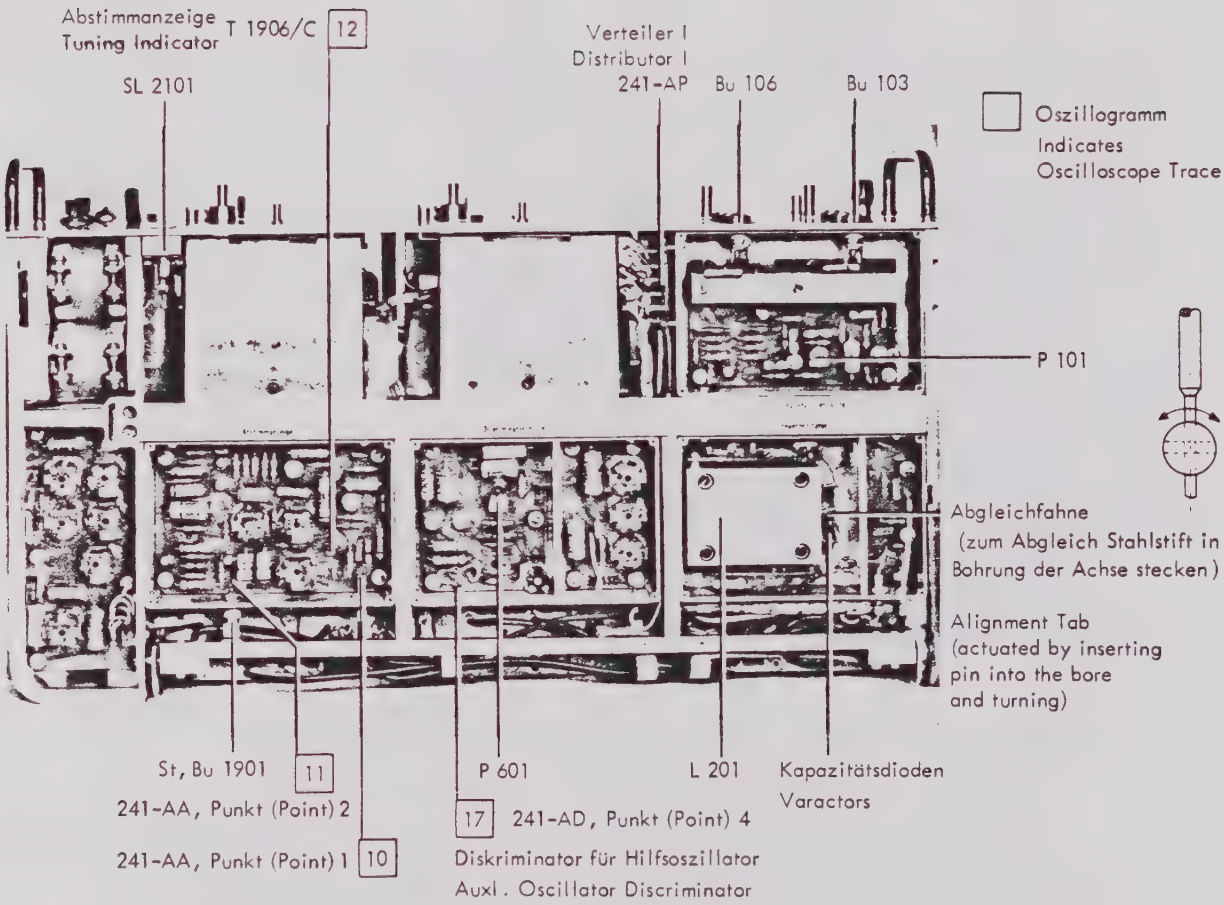



Bild 50 RWO-5 Ansicht von oben
Fig. 50 RWO-5 Top View

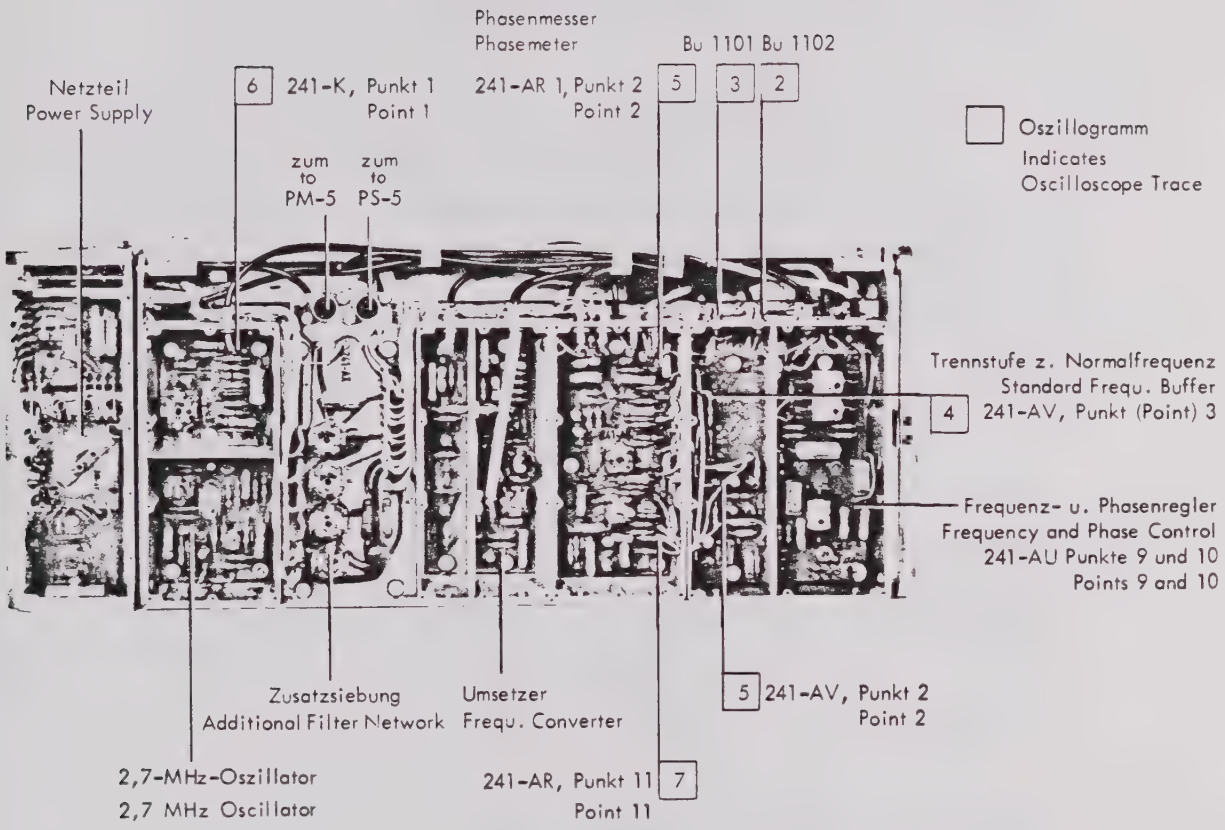



Bild 51 RWO-5 Rückansicht
Fig. 51 RWO-5 Rear View

## 5.2. Generator Portion PS-5

### 5.2.1. Operating Voltages

The current consumption and the operating voltages of each of the subunits can be checked against the following table. The current consumption is indirectly measured as the voltage drop across the filter resistor of the corresponding subunit.

| Subunit | Supply voltage in V | Current consumption in mA | Voltage across filter resistor in V |
|---|---|---|---|
| Final amplifier | + 36 | 88 | R 811 : 1.94 |
| Pre-amplifier | - 18 | 95 | R 704 : 2.1 |
| Converter +69 MHz amplifier | - 18 | 71 | R 504 : 1.56 |
| Hunting oscillator | - 18 | 0.27 | R 1305 : 1.0 |
| | + 36 | 0.27 | R 1302 : 0.27 |
| Phase control | - 18 | 29 | R 225 : 0.96 |
| 69 MHz oscillator | - 18 | 37 | R 104 : 1.2 |
| Amplitude control | - 18 | 36 | R 1005 : 1.2 |
| | + 36 | 31 | R 1006 : 1.0 |
| Limiter | - 18 | 52 | R 1104 : 1.7 |
| Attenuator | - 18 | 70 | |

Total current consumption: - 18 V : 390 mA
+ 36 V : 120 mA

### 5.2.2. Alignment of the 69 MHz Oscillator and Phase Control

Alignment of P 201 and C 108

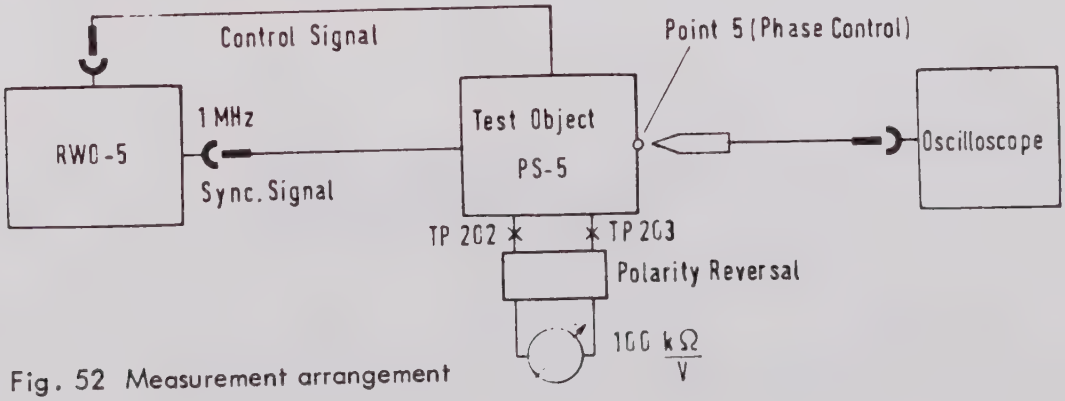



Fig. 52 Measurement arrangement

The aim of the alignment is to adjust P 201 and C 108 so that the hold range is approximately symmetrical to the control frequency and that the oscillator offers 69 MHz at a control frequency of 1 MHz. The cover of the oscillator sub-unit must remain closed during this alignment.

1. Disconnect the hunting oscillator and 69 MHz oscillator from point 5 of the phase control.
2. Place - 18 V on the disconnected lead to the 69 MHz oscillator. (This should cause a large detuning of the oscillator frequency by the varicap diodes).
3. Align the DC voltage at TP 202 and TP 203 with P 201 to read zero.
4. Reconnect the hunting oscillator and 69 MHz oscillator to point 5.
5. Adjust trimmer C 108 of the 69 MHz oscillator until the voltage at TP 202 and TP 203 is zero.

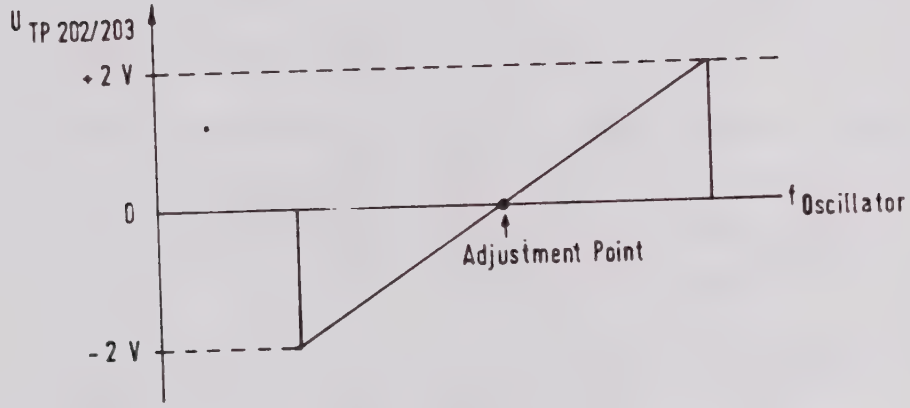



Fig. 53

Attention must be paid that this alignment is not carried out at 70 or 68 MHz. To establish this, set both frequency dials of the RWO-5 to 0 and ensure that the output signal of the PS-5 is absent. Lock trimmer C 108 with the locking nut.

### 5.2.3. Alignment of the 69 MHz Amplifier

Advance level potentiometer P 1002 until a voltage of approx. 20 mV is measured at test point 1 of the 69 MHz amplifier.

Measure the amplifier output voltage at test point 3 of the 69 MHz amplifier and align for maximum by alternately adjusting trimmers C 401 and C 406.

### 5.2.4. Adjustment of P 1003

Measure the base-emitter voltage of T 1004 with a multimeter in 300 mV range.

$Z_{out}$ selector S 902 to 50 Ω
Switch S 1001 to "Power Level" position
Adjust level control P 1002 for the following values on the meter:

| | |
|---|---|
| dB unit with meter No. 242 - 8101 | 1.2 V (on 10 V scale) |
| dB unit with meter No. 242 - 8104 | 1.0 V (on 10 V scale) |
| Np unit with meter No. 242 - 8102 | 0.5mm below - 2 Np |
| Np unit with meter No. 242 - 8105 | - 2 Np |

After this, adjust the base-emitter voltage of T 1004 with P 1003 to - 50 mV and simultaneously hold the above indication on J 1001 by adjusting P 1002.

### 5.2.5. Checking the Adjustment Range of P 1002

Check to see if the following adjustments on the meter can be made:

1) An indication of more than + 2 dB (+ 0.2 Np) at $Z_{out}$ = 150 Ω and "power level".
2) A lower indication than 1 V (- 2 Np) at $Z_{out}$ = 50 Ω, "power level" and with the amplitude control in and out of circuit.

## 5.3. Receiver Portion PM-5

Fundamentally speaking, the operating points of all circuits can be checked with the aid of the information given in the circuit diagrams.
All voltages were measured with a 100 kΩ/V voltmeter against ground. The current consumption is mainly calculated from the voltage drop across the relative filter resistor. The amplification and attenuation levels are given in the level plan, whereby the voltage levels of the balanced circuits are also measured against ground. The relay plan indicates which relays are energized (see page 121). In addition to this various sub-units have individual test and alignment instructions.

### 5.3.1. Terminating Resistors

Operational check: Measure with an ohmmeter at the input socket.
With pushbutton S 1801/7 released: high-impedance.

With pushbutton S 1801/7 depressed: The impedance value selected at S 101.

Accuracy of the DC values: 0.5 %

Resistor combinations:

| Z / Ω | Relay No. | Resistor R / Ω |
|---|---|---|
| 50 | 104, 101 | 75, 150 |
| 60 | 104, 102 | 75, 300 |
| 65 | 104, 103 | 75, 487,5 |
| 75 | 104 | 75 |
| 135 | 106,105 | 150, 1350 |
| 150 | 106 | 150 |

The relay voltage must amount to at least 16 V. It is important that the threaded bolts are securely screwed into the pole shoes and that no air gap is formed which would increase the magnetic resistance.

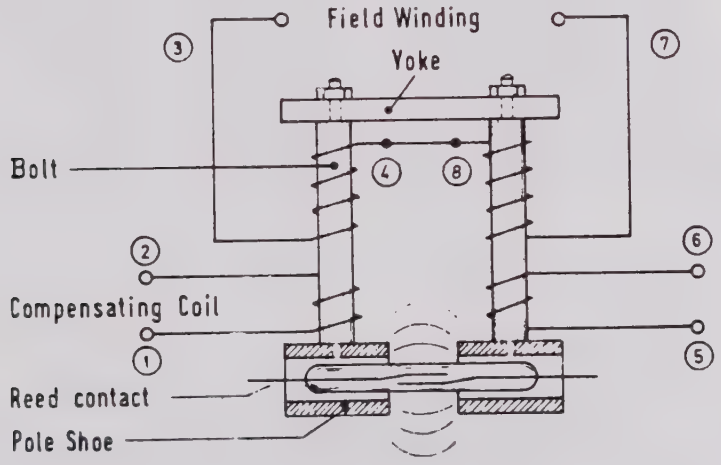



Fig. 54 Assembly of the magnetic portion

The reflection coefficient of the input resistors of an operational Level Meter PM-5 can be measured with a return loss measuring bridge (e.g. RFZ-5). An alignment is, however, only provided at 75 Ω impedance for a measuring frequency of 15 MHz. Large errors will also be seen as frequency response errors if the receiver is operated under terminated conditions.

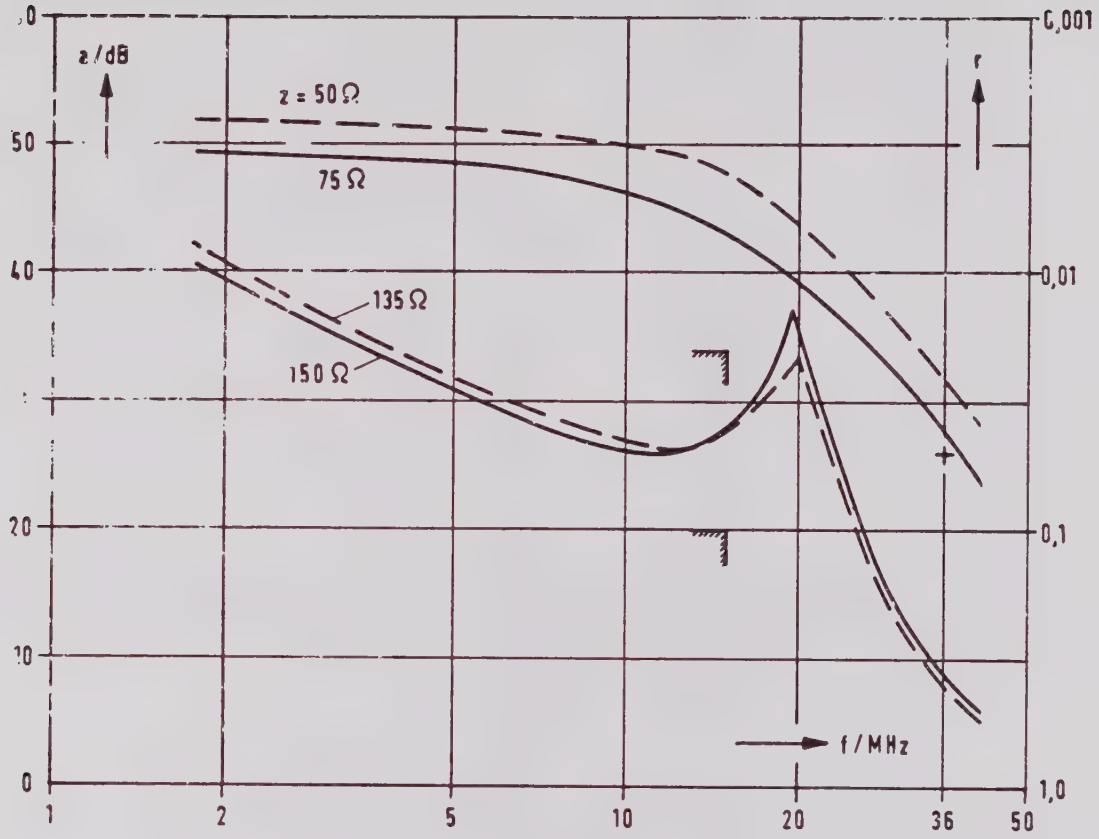



Fig. 55 Return loss in the 0 dB, low noise position

5.3.2. 10 dB (4 Np) Pre-attenuator and Input Capacitance

5.3.2.1. Alignment of the Attenuator:

Set PM-5 to -40 dB (- 4 Np) low noise and connect Scale Expander AZD-1. Place a generator output level of 0 dB at 100 kHz via a calibrated attenuator or attenuation measuring set of 40 dB to the receiver input. Switch the PM-5 to 0 dB (0 Np) and set the calibrated attenuator to 0 dB. Align C 108 for the same indication on the AZD-1.

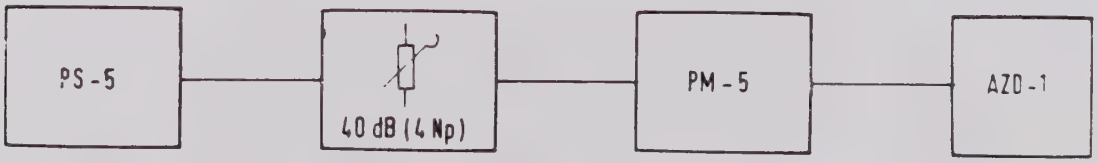



Fig. 57

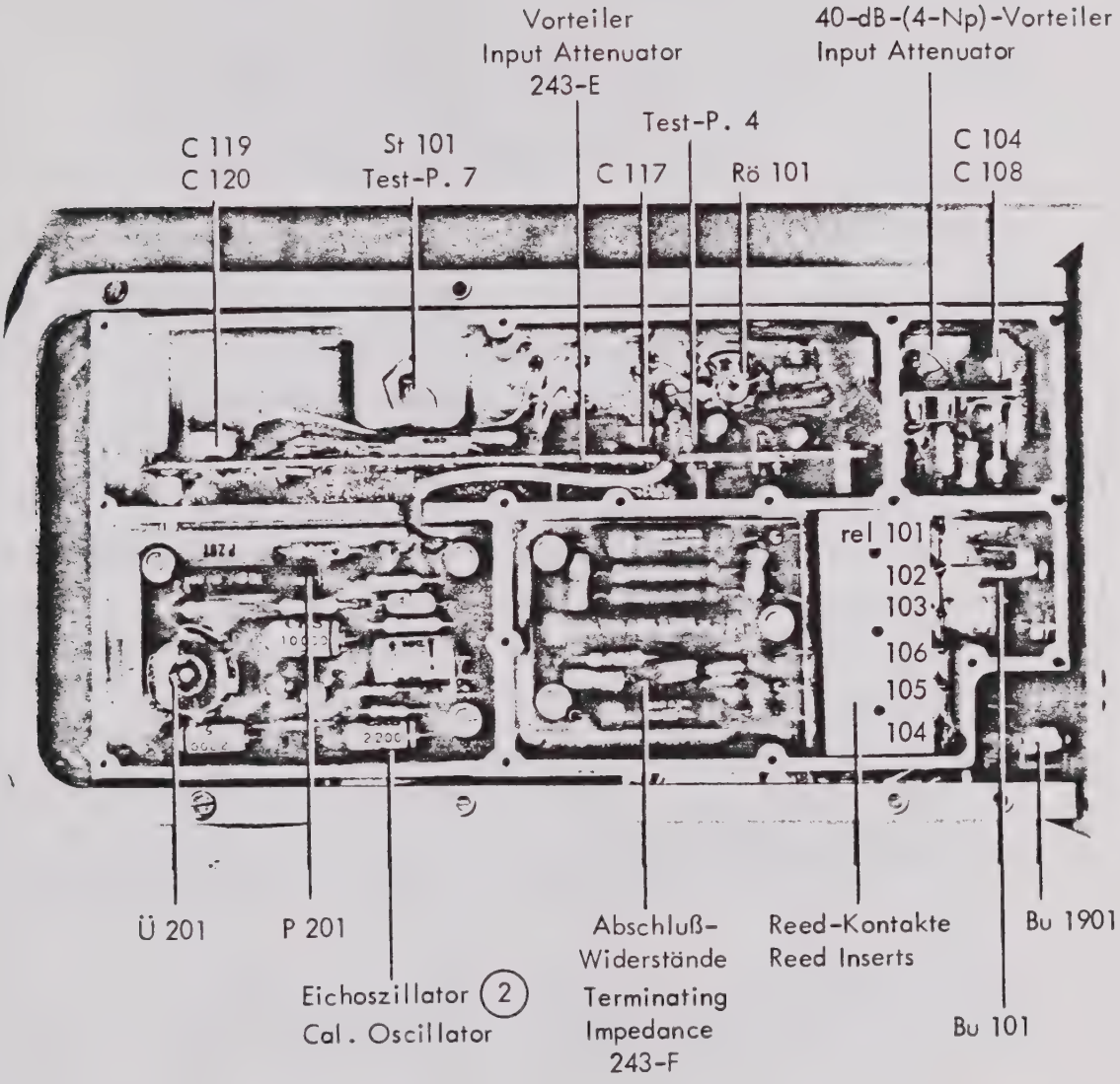



Bild 56 PM-5 Eingangsbaustein
Fig. 56 PM-5 Input Network

5.3.2.2. Input Capacitance:

Measure the input capacitance at socket Bu 101 with an LC meter in position -40 dB (- 5 Np) low noise and "$R_e = 1/\omega C_e$".

Nominal value: 28 pF.

Switch to 0 dB (- 1 Np) and align C 104 for the same capacitance reading.

The capacitance curve as a function of frequency is shown in Fig. 59.

5.3.3. Cathode Follower Stage

The cathode current of the tube should be 40 mA. Adjust P 1901 on the main distributor for a reading of 12 V at the cathode of tube Rö 101.

The voltage is measured with a 100 kΩ/V voltmeter against ground.

5.3.4. Calibration Oscillator

The calibration oscillator can be aligned after depressing the calibration button and allowing a warm-up period of one hour.

Connect a Frequency Counter FZ-1 to Tp 4 of circuit board 243-E and align Ü 201 to 100 kHz ± 100 Hz.

To carry out the level measurement, connect a level standard (e.g. PN-27 of W u. G) of 100 kHz at 0 dB (0 Np) to the PM-5 input "$R_e = 1/\omega C_e$". Set PM-5 to 0 dB (0 Np) low noise and adjust linear calibration potentiometer P 1501 for a 0 dB (0 Np) reading on the Scale Expander AZD-1. Depress calibration button linear and align P 201 for the same reading.

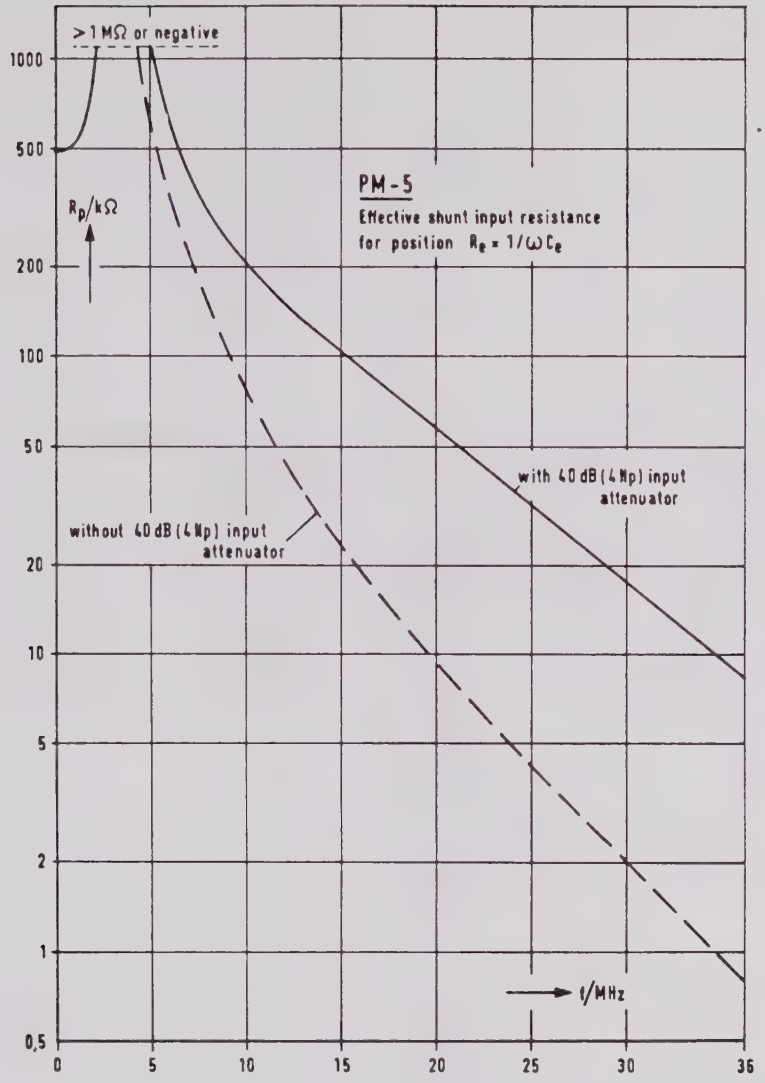
The RWO-5 should be always tuned for maximum after switching.

The calibration level is also valid for the logarithmic mode.

5.3.5. Pre-amplifier

The alignment value of R 314 determines the DC distribution in the differential amplifier stage T 303/T 304. Its setting is so chosen that a voltage of - 2.65 V (series A to E) or - 2.90 V (commencing with series F) is available at the collector of T 304 if the DC operating points have been correctly set.

The frequency response of the pre-amplifier has, according to the alignment of L 301, a loss of approx. 2 dB at 36 MHz.




With 40 dB ( 4 Np ) input attenuator: + 20, + 10, ..., -10 dB ( + 2, + 1, ..., - 2 Np ) low noise
+ 20, + 10, ..., -70 dB ( + 2, + 1, ..., - 8 Np) low distortion

Fig. 58 Without 40 dB ( 4 Np ) input attenuator: all other sensitivity positions

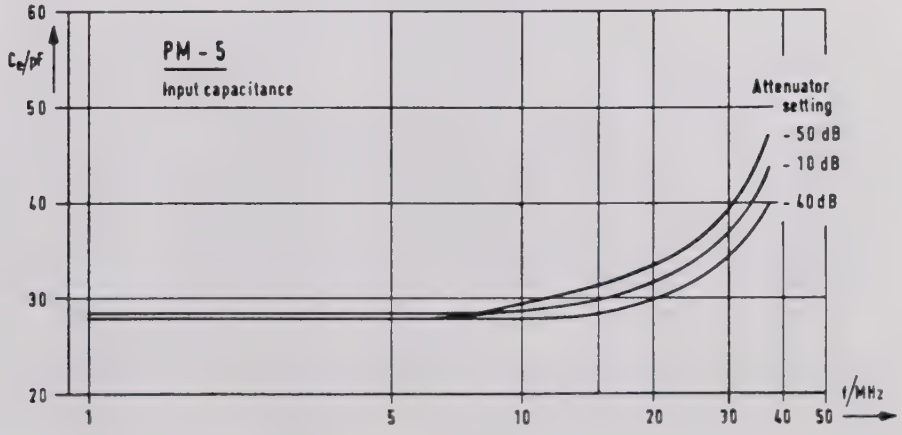



Fig. 59

### 5.3.6. 36 MHz Low-pass Filter

The inductances and trimmers have been aligned to their nominal values before assembly. An alignment of the optimum attenuation in the pass band up to 36 MHz is not possible. However, it is possible to align the insertion loss to minimum at the cut-off frequency with C 410. The trimmers C 402, C 406 and C 411 are aligned for attenuation peaks at 174 MHz, 69 MHz and 137.5 MHz. This is achieved by connecting a power signal generator (eg. LMS-68), adjusted to a level of 0 dB, to the input of the PM-5. The IF or image rejection can be now aligned for a minimum indication in the - 70 dB (- 8 Np) position. The input level is measured with the aid of a RF-millivoltmeter.

| Input frequency | Frequency tuned at RWO-5 | Alignment trimmer |
|---|---|---|
| 69 MHz | any | C 406 |
| 137.5 MHz | - 0.5 MHz | C 411, commencing with series D |
| 174 MHz | 36 MHz | C 402 |

The input frequency can be compared with a spectrum generator (eg. General Radio type 1213).

### 5.3.7. Limiter for 69.01 to 105 MHz

This limiter requires an input voltage of $U_{r.m.s} \approx 0.5$ V; a maximum of 2 V is permissible. The voltage at output Tp. 2 on circuit board 243-R is limited to values between $U_{r.m.s.} = 2.8$ V at 69 MHz and 2.2 V at 105 MHz.
The output voltage can be measured in dependence of the input voltage with the Hewlett Packard mV-Meter 411 A.

### 5.3.8. 69 MHz Bandpass Filter

Attenuation peak alignment at 54.12 MHz: Place a level of 0 dB at 18.88 MHz to the receiver input. Tune the RWO-5 to 4 MHz to receive the image frequency of Mixer II. Increase the sensitivity at the PM-5 until the reading is clearly visible. Adjust C 711 for minimum. Nominal value: -80 dB (- 9 Np).

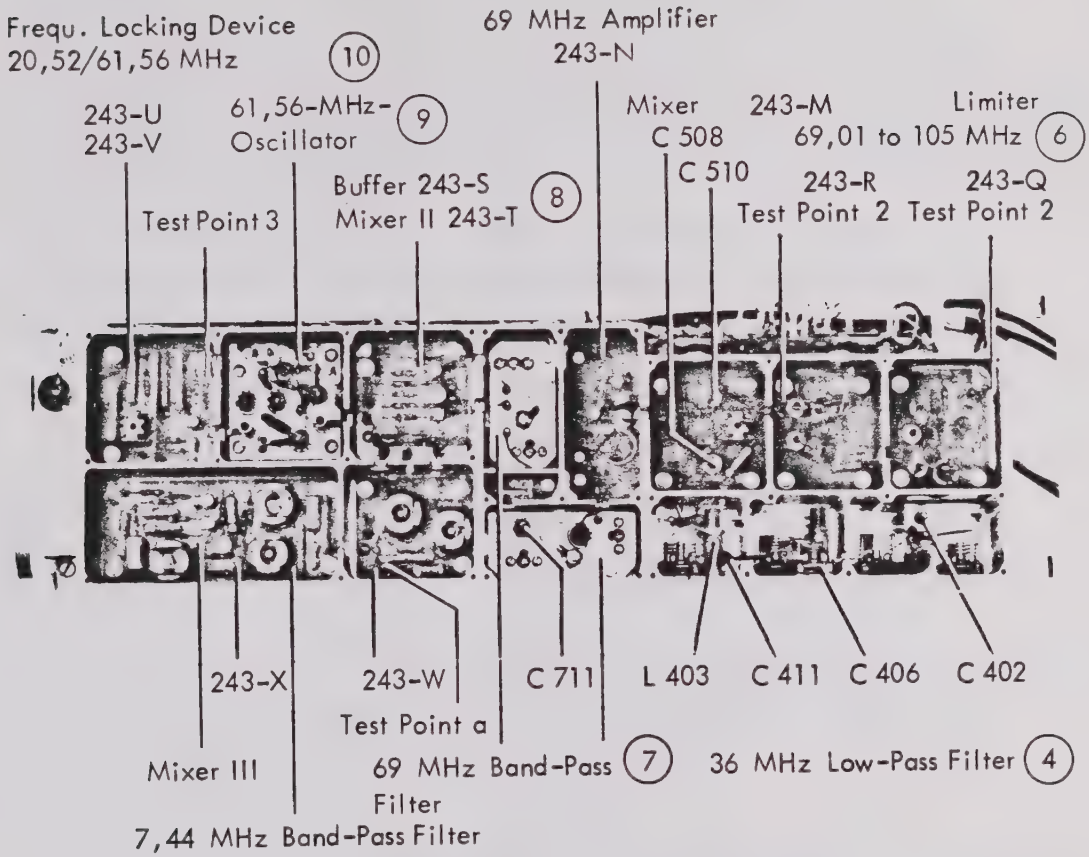



Fig. 60 PM-5 Rear View

| | | |
|---|---|---|
| Frequency conversion: | Carrier frequency 69 MHz + 4 MHz | 73 MHz |
| | - input frequency | 18.88 MHz |
| | 1st IF | 54.12 MHz |
| | - carrier II | 61.56 MHz |
| | 2nd IF (image) | - 7.44 MHz |

The coupling link L 701 (for series A to C) or C 707 (commencing with series D) is aligned before assembly in a special measuring arrangement. A subsequent alignment is not possible. The bandwidth and insertion loss of the filter are dependent of this alignment. The shunting stages with C 712, C 708, C 706 and C 704 can, if necessary, be aligned for maximum reading on receiving a signal. It is, however, better to tune each stage to 68.6 MHz, during which the adjacent stages must be damped with 100 Ω.

## 5.3.9. 7.44 MHz Bandpass Filter, 600 kHz Bandpass Filter

The links of both bandpass filters are decoupled during the alignment by replacing bridges a to d with 1 pF capacitors.

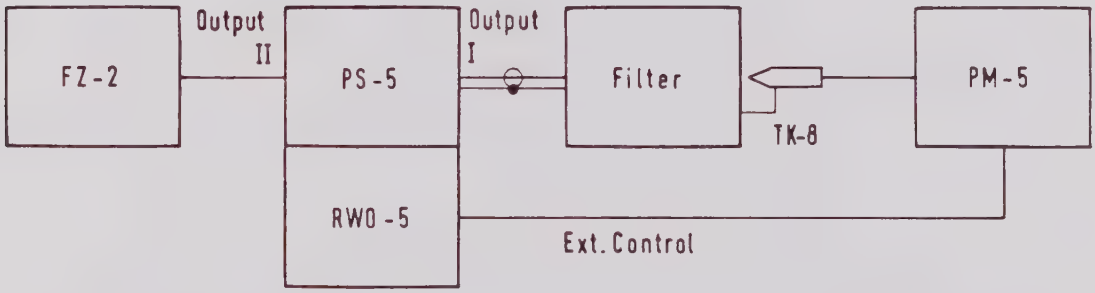



Fig. 61 Measuring arrangement

Alignment of the 7.44 MHz filter:

Disconnect R 818 at the ground end and feed approx. - 15 dB at $Z_{out}$ = 50 Ω via a short connection to the disconnected end of the resistor. Connect the probe to point 4 of circuit board 243-X (base of T 1103). Adjust the alignment pins of Ü 1101, L 1101, L 1102 and Ü 1102 for a maximum reading at f = 7.640 MHz ± 1 kHz. Repeat alignment.

Alignment of the 600 kHz filter:

Remove the bridge between points 5 and 6 of circuit board 243-X and feed - 15 dB at $Z_{out}$ = 50 Ω to R 1118. Connect the probe to point 1 of circuit board 243-O. Reading should be approx. - 110 dB. Adjust Ü 1105, L 1104, L 1201 and Ü 1201 for

a maximum reading at f = 613 kHz ± 50 Hz. Repeat alignment and reconnect bridges.

### 5.3.10. 61.56 MHz Oscillator and Phase Locking Device

The third harmonic of the 6.84 MHz oscillator is fed via a bandpass filter to the frequency locking device. Connect an oscilloscope (eg. OS-1 with TK-4 from W u. G) to point 3 of circuit board 243-U and measure the 20.52 MHz voltage. Align Ü 1104 and Ü 1001 for maximum amplitude.

Nominal value: $U_{pp} \approx 1.6$ V

The oscillator voltages can be measured with the hp mV Meter type 411 A.

Nominal values Base of T 902: 0.8 V

Collector of T 902: 1.2 V

Collector of T 903: 1.0 V

For information regarding the alignment of the hold range see Section 4.3.2.2.

### 5.3.11. 6.84 MHz Oscillator and Phase Locking Device

The third harmonic of the 570 kHz crystal oscillator serves as synchronizing frequency. Connect an oscilloscope via the probe to point 5 of circuit board 243-O and align the 1.71 MHz voltage for maximum amplitude at Ü 1202.

Nominal value: $U_{pp} \approx 3$ V

For information regarding the alignment of the hold range see Section 4.3.2.2. and oscillograms 30 to 35 of Section 6.3.

### 5.3.12. 30 kHz Bandpass Filter

5.3.12.1. Checking the selectivity curve of the PM-5, which essentially corresponds to that of the bandpass filter.

The easiest manner is to obtain the attenuation curve using the Sweep Measuring Set WM-50. Switch the PM-5 to "CAL": Calibration linear for checking the pass band, and logarithmic for checking the stop band range. Connect the SGE-10 to the PM-5 and RWO-5 and adjust the sweep width to the frequency range of interest. Centre frequency 100 kHz. The selectivity curves are given in the operating manual of the PSM-5. See also Section 1.1.3.4.

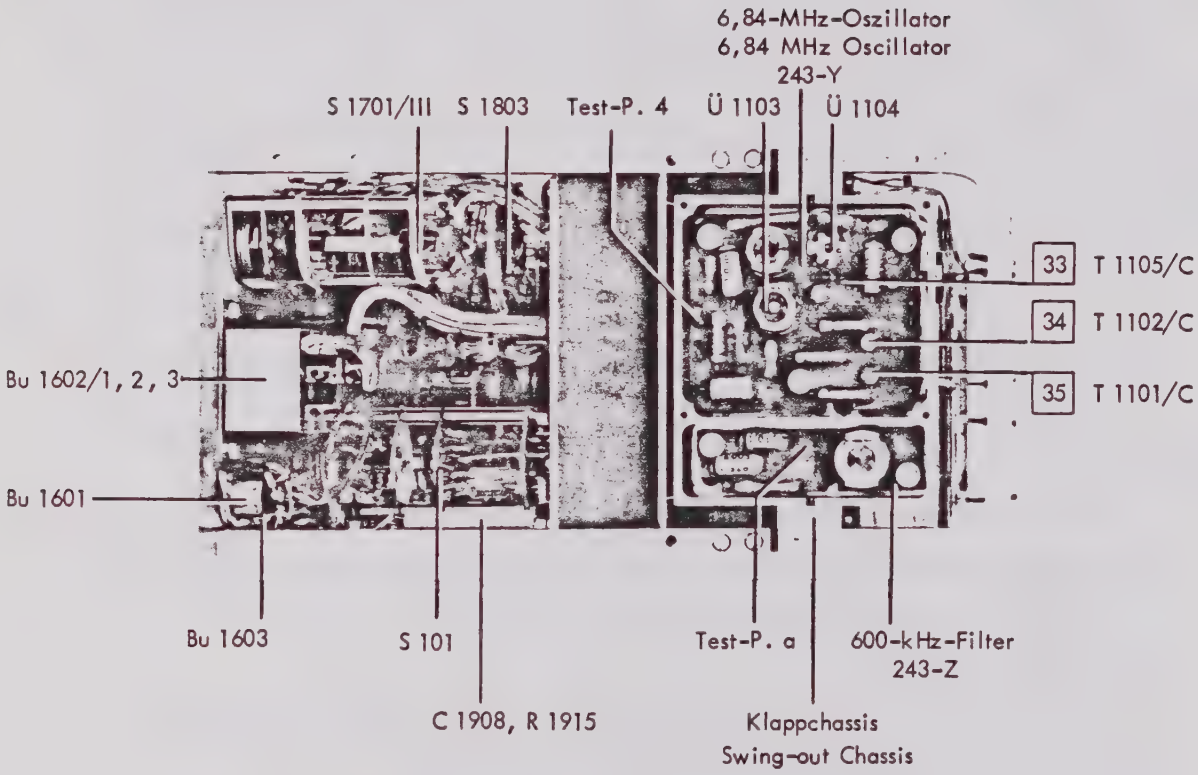



Bild 62 PM-5 Seitenansicht
Fig. 62 PM-5 Side View

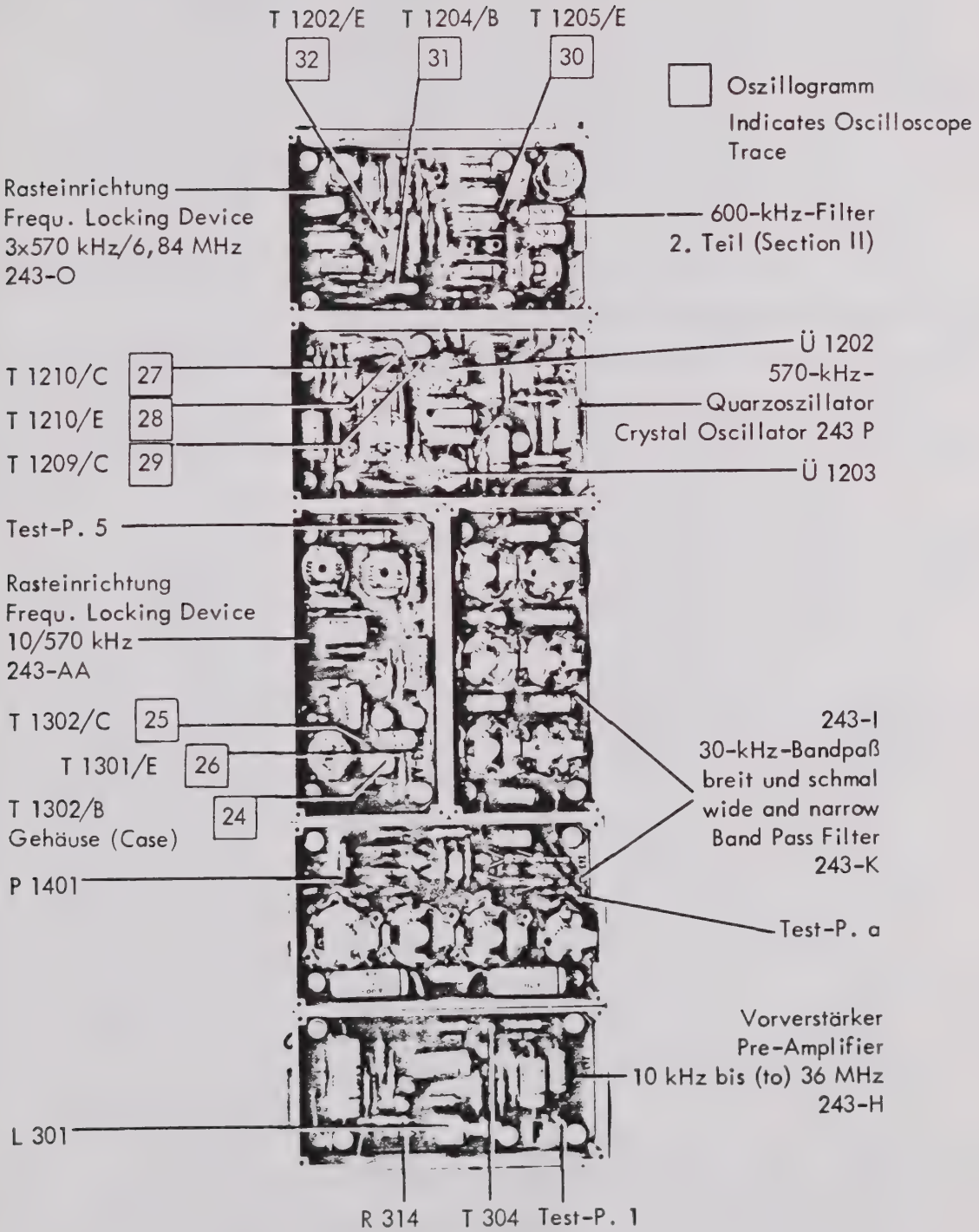



Bild 63 PM-5 Klappchassis Innenseite
Fig. 63 PM-5 Swing-Out Chassis (internal view)

The pass band range can also be checked with the scale expander: PM-5 to linear calibration, connect AZD-1 to socket Bu 1603 and the frequency counter to Bu 1602/2. The minimum attenuation point should be at 30 kHz at 500 Hz bandwidth. No dips on the attenuation curve should be visible when slowly tuning the frequency.

5.3.12.2. Alignment of the 30 kHz bandpass filters

The alignment of the wideband portion is critical and must be individually made for each stage. An alignment according to the curve form is, due to the large number of parameters, not possible.

The narrow band filter can be aligned in its assembled condition by adjusting for a maximum level reading at 30 kHz:

PM-5 to linear calibration, bandwidth to 500 kHz, FZ-1 to 30 kHz output and tune RWO-5 to 30 kHz.

Adjust Ü 1403, L 1403, L 1406 and Ü 1404 for the greatest level indication at the scale expander. Repeat alignment.

5.3.12.3. Insertion loss compensation

The minimum attenuation point of the narrow band filter normally lays at 30 kHz. PM-5 to linear calibration and narrow bandwidth. Tune RWO-5 to 100 kHz, ie. for maximum reading on the PM-5 or AZD-1. Adjust P 1501 for a 0 dB (0 Np) reading. P 1401 is adjusted for the same reading after switching to wideband. The 3.5 kHz filter is so flat within its passband that it is not necessary to retune the RWO-5.

If the minimum attenuation point no longer lays at exactly 30 kHz, the attenuation compensation is best made at the greatest calibration level reading of the PSO-5, whereas with the PSM-5, the attenuation compensation must be made at the exact IF frequency of 30 kHz. It is thus necessary to coincide the reading to the generator level of the PS-5 with the aid of P 1401 and not to the calibration level. The calibration of the instrument must then be carried out in the "3.5 kHz" bandwidth position.

5.3.13. Logarithmic Circuitry

5.3.13.1. Alignment of C 1602

Feed a 100 kHz signal at - 100 dB to the receiver input. Switch the PM-5 to measuring

range "0 dB (0 Np) log" and tune with the RWO-5 to 100 kHz. Align C 1602 for maximum reading.

Nominal value : - 100 dB (- 10 Np).

5.3.13.2. Logarithmic characteristic curve

Feed - 90 dB (- 9 Np) to the input of the PM-5. Adjust P 1601 (shift) to the scale marker - 90 dB (- 9 Np). Commencing with production series E, this adjustment is made with P 1903, whereby P 1601 should remain in its centre position.

Feed - 20 dB (- 2 Np) to the input and adjust P 1902 (expansion) to the - 20 dB scale marker.

Repeat alignment

During operation, the calibration is made only with potentiometer P 1601 to the calibration marker - 20 dB (- 2 Np) because the expansion of the characteristic curve remains unchanged. The range of adjustment should amount to ± 8 dB (± 1 Np).

The linearity of the logarithmic scale can be checked with an attenuator test instrument or a calibrated attenuator.

The reference point is the - 20 dB (- 2 Np) scale marker. The measuring arrangement is as described in Section 4.3.3.1.

## 5.3.14. Output Sockets

The specified values given in Section 1.1.3.6. of the operating manual should be available at these sockets. A DC voltage is available between contacts 4 (-) and 5 (+) of sockets Bu 1601 and Bu 1603.

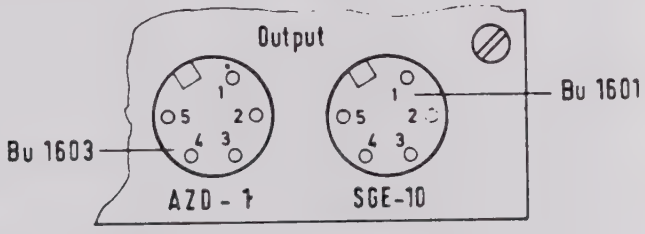



Fig. 65

## 5.3.15. Frequency Conversion Oscillator for the Demodulation of SSB Signals.

The oscillator frequency can be measured by connecting a frequency counter, via an isolating capacitor of 0.5 µF, to point 1 of circuit board 243-A. A square wave

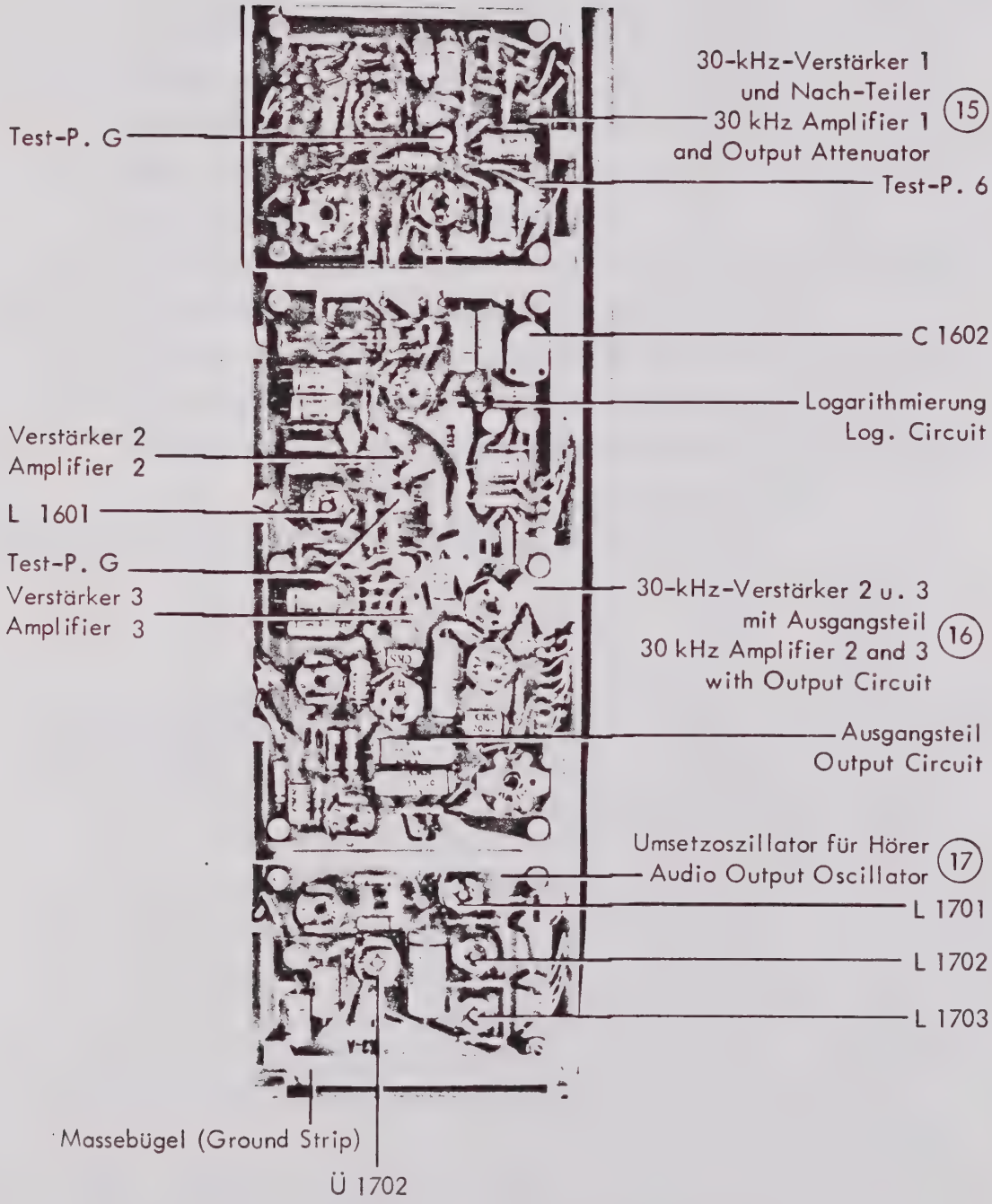



Bild 64 PM-5 Zwischenchassis
Fig.64 PM-5 Interm. Chassis

signal at an amplitude of $U_{pp}$ = 220 mV should be available. This voltage can also be measured at the slider of switch S 1701/III.

Frequency alignment:

| Switching position | | Frequency | Align |
|---|---|---|---|
| S 1701 | S 1801/6 | f/kHz | |
| | 3.5 kHz<br>500 Hz | 28<br>29 | Ü 1702<br>L 1701 |
| | 500 Hz<br>3.5 kHz | 31<br>32 | L 1702<br>L 1703 |

The bias current for the zero suppression amounts to approximately 110 µA during logarithmic operation of the dB model and approximately 160 µA for the Np model. Select the linear mode and connect a µA meter between point 3 and 4 of circuit board 243-A. The bias current can now be read from the µA meter.

### 5.3.16. Voltage-free Front Panel

No galvanic connection should be present between the chassis and the front panel of the PM-5 if the power supply plug St 1901 and the control voltage are disconnected (remove plug connection at the RWO-5).

Connect an ohmmeter between the front panel and ground point of socket Bu 1602/1.

Nominal value:$\infty$

The RF isolation is made, during normal operation, by filter chokes in the ground connection and a choke in the control voltage channel.

## 5.4. Scale Expander AZD-1

### 5.4.1. Opening the Cabinet

Remove the holding screws and detach rear cover.

The calibration potentiometer is to be found on the rear panel (Commencing with series D, this control is mounted on the front panel). It is thus necessary to carefully handle so that the connections are not broken.

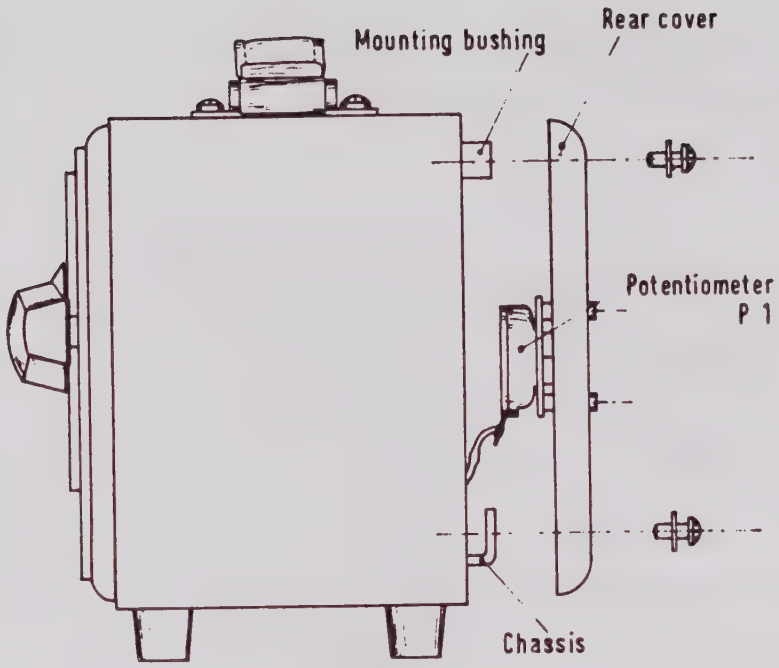



Fig. 66

### 5.4.2. Removing the Unit from its Cabinet

Remove the control knob from the attenuation selector. Lay the unit on the rear cover and remove feet. Remove the unit from the cabinet by depressing the switch shaft.

### 5.4.3. Current Consumption

Open the cabinet of the AZD-1 and connect to the PM-5. Remove the lead from point 3 of the scale expander and connect an ammeter between same. Place the AZD-1 attenuation switch S 1 to +1 dB (+ 0.1 Np). Depress the linear calibration button of the PM-5, tune the RWO-5 to 100 kHz and adjust the calibration potentiometer S 1501 of the PM-5 for a reading of +1 dB (+ 0.1 Np).

Measure the current consumption.

Nominal value: 10 to 10.6 mA.

Reconnect lead to point 3.

Measure the voltage across Gl 3 and Gl 4.

Nominal value: 8.3 to 9.6 V.

### 5.4.4. Checking the Attenuator

Select linear calibration at the PM-5 and adjust the calibration potentiometer for a reading of + 1 dB (+ 0.1 Np). Place the attenuation switch S 1 of the AZD-1 to + 1 dB (+ 0.1 Np). Adjust AZD-1 calibration potentiometer P 1 for a 0 reading. Reduce the reading on the PM-5 meter in steps of 1 dB with the calibration potentiometer P 1501, at the same time switching the AZD-1.
The reading on the AZD-1 must remain within ± 0.06 dB (± 0.006 Np) of the zero marker.

### 5.4.5. Checking the Expansion Adjustment (P 3)

Place the AZD-1 attenuation switch to - 2 dB (- 0.2 Np) and adjust the PM-5 calibration potentiometer for a - 1 dB reading. Adjust P 1 for a reading of +1 dB (+ 0.1 Np) on the AZD-1. Adjust the calibration potentiometer P 1501 for a -3 dB (- 0.3 Np) reading on the PM-5. If P 3 is correctly adjusted, the AZD-1 should now show a reading of exactly - 1 dB (- 0.1 Np). These tests can only be classed as a rough operational check and it is necessary to use special equipment, including a precision attenuator and a means of reconstructing the output level of the PM-5, to carry out an accurate calibration and check. This is especially true when the adjustment of P 2 for the balance of the differential amplifier or P 3 for the scale expansion is necessary.
The following measuring arrangement can, however, be used with advantage:

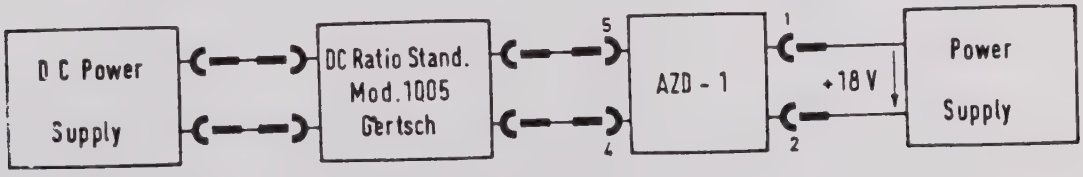



Fig. 67

Place AZD-1 potentiometer P 1 in its mechanical centre position. Place the attenuator switch to 0 dB (0 Np).
Adjust the DC power supply for a 0 reading on the AZD-1.
All divider positions can be checked with the aid of the following table:

a) dB model

| Position of the AZD-1 attenuator switch | Reading on AZD-1 | DC Ratio Stand. |
|---|---|---|
| + 1 | + 1 | 97 500 |
| + 1 | 0 | 86 900 |
| 0 | 0 | 77 500 |
| - 1 | 0 | 69 000 |
| - 2 | 0 | 61 500 |
| - 3 | 0 | 54 800 |
| - 4 | 0 | 48 900 |
| - 5 | 0 | 43 600 |
| - 6 | 0 | 38 800 |
| - 7 | 0 | 34 600 |
| - 8 | 0 | 30 800 |
| - 9 | 0 | 27 500 |

b) Np model

| Position of the AZD-1 attenuator switch | Reading on AZD-1 | DC Ratio Stand. |
|---|---|---|
| + 0.1 | + 0.1 | 99 999 |
| + 0.1 | 0 | 90 500 |
| 0 | 0 | 81 900 |
| - 0.1 | 0 | 74 100 |
| - 0.2 | 0 | 67 100 |
| - 0.3 | 0 | 60 700 |
| - 0.4 | 0 | 54 900 |
| - 0.5 | 0 | 49 700 |
| - 0.6 | 0 | 44 900 |
| - 0.7 | 0 | 40 700 |
| - 0.8 | 0 | 36 800 |
| - 0.9 | 0 | 33 300 |

### 5.4.6. Alignment of the Attenuator

A warm-up period of at least 15 minutes is necessary before carrying out the alignment.
Switch the attenuator selector of the AZD-1 to +1 dB (+ 0.1 Np).
Place potentiometer P 1 to its mechanical centre position. Set the DC ratio standard to 86 900 for the dB model or 90 500 for the Np model. Adjust the DC voltage until a 0 reading is obtained at the AZD-1. Set the attenuator selector to - 7 dB (- 0.7 Np) and adjust the DC ratio standard to 34 600 for the dB model or 40 700 for the Np model. Adjust the balance potentiometer P 2 for a zero reading at the AZD-1.
Check the zero adjustment in position + 1 dB (+ 0.1 Np) and realign if necessary. Continue alternate alignment until the 0 point is correct in both positions. The alignment should always be ceased with P 2.

### 5.4.7. Expansion Adjustment

Place potentiometer P 1 in its mechanical centre position.
AZD-1 attenuation switch to -2 dB (- 0.2 Np) and DC ratio standard to 69 000 (74 100).
Adjust the DC voltage for a reading of +1 dB (+ 0.1 Np) on the AZD-1. Set DC ratio standard to 54 800 (60 700) and adjust P 3 for a reading of -1 dB (- 0.1 Np) on the AZD-1.
Repeat alignment until the meter reading remains at full right and full left scale on switching the DC ratio standard.

## 5.5. Probe TK-8

### 5.5.1. Current Consumption and Operating Points

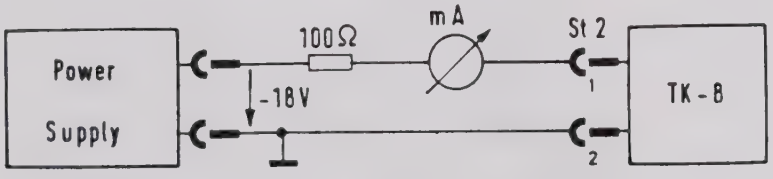



Fig. 68 Measuring arrangement

Connect the TK-8 via a dropper resistor to -18 V.
Measure the current consumption.
Nominal value: 50 mA.

Check the following DC voltages:

| | |
|---|---|
| Base of T 1 | U = - 5.3 V |
| Emitter of T 2 | U = - 6.9 V |
| Across C 3 | U = - 9.7 V |
| Across C 5 | U = - 12.9 V |
| Emitter of T 3 | U = - 7.9 V |

## 5.5.2. Attenuation Alignment

Connect the probe to the PM-5 and measure the output voltage at output I of the PS-5.

Select 100 kHz at the RWO-5 and calibrate PM-5. Input impedance to "$R_e = \frac{1}{\omega C_e}$.

Adjust for a -6 dB (0.7 Np) reading at the PS-5.

Place P 1 in its centre position and adjust the probe attenuation with P 2 for a -2 dB (- 0.2 Np) reading at the PM-5.

## 5.5.3. Frequency Response

The probes used are individually aligned in the factory in conjunction with the relative receiver unit. If the probe is obtained at a later date, an alignment of the frequency response will be necessary.

The following 3 measuring arrangements are recommended for this alignment:

1. Method :

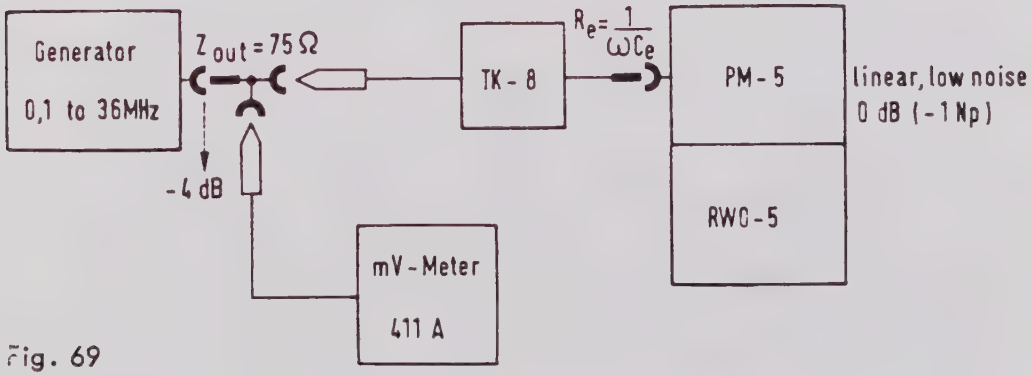



Fig. 69

The above measuring arrangement is used when the TK-8 is to be used in conjunction with a PMO-5.

The following additional equipment is required: A signal generator with a frequency range of 100 kHz to 36 MHz and a harmonic distortion factor better than 1 %, together with a RF millivoltmeter to monitor the input signal of the probe, which must remain constant over the whole frequency range.

The alignment of the probe is carried out in the 0 dB (- 1 Np) position of the PM-5.

Adjust P 1 and C 2 for the flatest frequency response curve (P 1 up to 15 MHz and C 2 at 36 MHz).
Nominal value: max. deviation from ideal curve ± 2 %.

2. This alignment is simplified if the TK-8 is to be used with a PSM-5, because the input level for the probe is automatically held at a constant level throughout the whole frequency range.
   Set the PS-5 for a -10 dB (- 1.15 Np) output level reading. A level of - 4 dB (- 0.46 Np) is thus available at the generator output and the harmonic distortion factor remains less than 1 %.

3. The best method is however, to display the frequency response curve during swept frequency operation. For this, a Display Unit SG-1 and the matching Plug-in Unit SGE-10 are required in addition to the PSM-5.

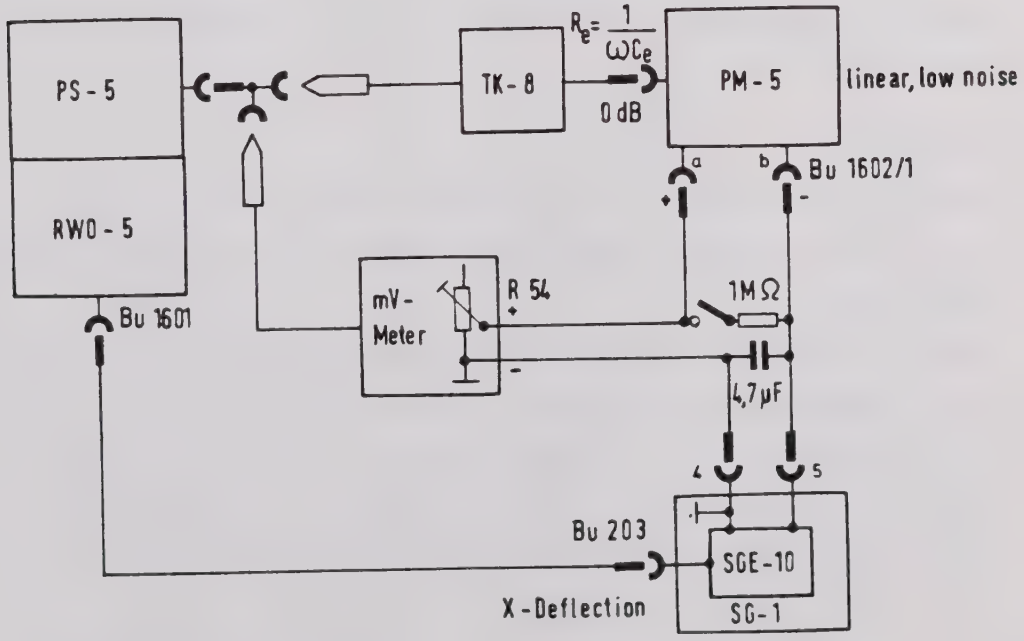



Fig. 70 Measuring arrangement

Place the PS-5 attenuator to 0 dB (- 1 Np) and adjust for a meter reading of - 10 dB (- 1 Np). The harmonic distortion factor will thus remain below 1 %.
Adjust the attenuator of the RF millivoltmeter so that a reading of approximately f.s.d. is obtained.
Switch the PM-5 to the 0 dB (- 1 Np) position.
Adjust the calibration potentiometer for f.s.d. reading at the PM-5. Adjust the DC output voltage of the RF millivoltmeter with R 54 so that it is equal to that of the DC voltage of the PM-5 but in opposite sense, i.e. coincide the frequency response curve and fly-back trace at the display unit.
The display should be shifted by 1 cm in position "x 10" on placing the 1 MΩ resistor parallel to the output impedance of the sweep frequency output of the PM-5, providing that the Y-amplification of the SGE-10 is correct.

Measurement :

Sweep width : ± 17.5 MHz

Sweep frequency : 0.2 Hz

Centre frequency : 18.5 MHz

The alignment of the probe is carried out in the 0 dB (- 1 Np) position of the PM-5.

Adjust P 1 at approximately 15 MHz and C 2 at 36 MHz for the flatest frequency response curve.

Nominal value : within ± 2 %.

Checking PM-5 sensitivity positions + 20 dB (+ 1 Np) to - 50 dB (- 6 Np).
The frequency response deviation in the above positions is measured after completing the alignment.
Select the corresponding sensitivity at the PM-5 and RF millivoltmeter and similarly vary the generator level. The frequency response curve displayed on the display unit will be shifted due to the attenuator error of the connected units. The deviation at 1 MHz is corrected with the "Y-MAG" potentiometer on the SGE-10. The deviations from the 0 dB (- 1 Np) curve are now established in the individual attenuator positions.

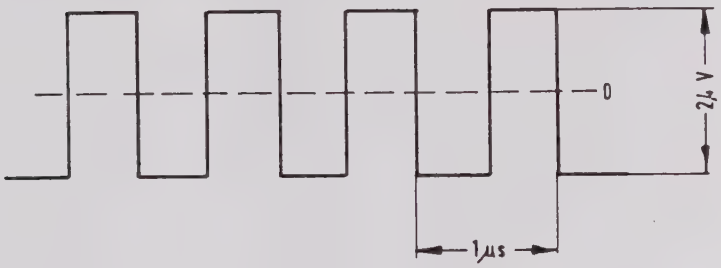
The attenuator position + 10 dB (0 Np) low noise corresponds the - 10 dB low distortion position.

A voltage of - 3 V is fed to point 5 of circuit board 243-L for the + 10 dB and 0 dB (0 Np and - 1 Np) values.

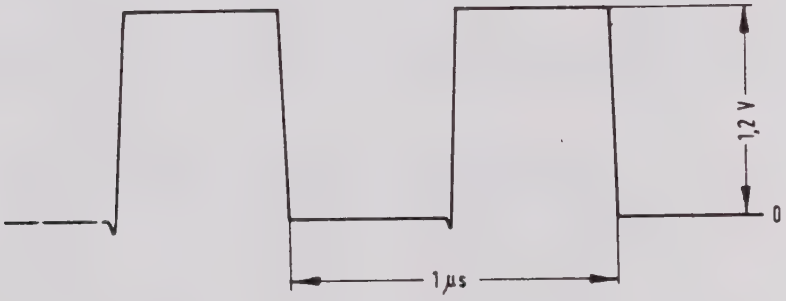
Nominal value : The deviation from the 0 dB (- 1 Np) curve should be within ± 1 %.

## 6.1 Oszillatorteil (Control Oscillator) RWO-5

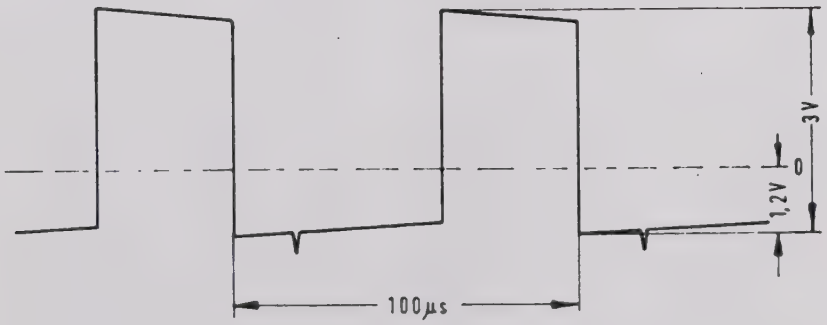
1 Normalfrequenz-Oszillator
Standard Frequ. Oscillator (13) Bu 1303



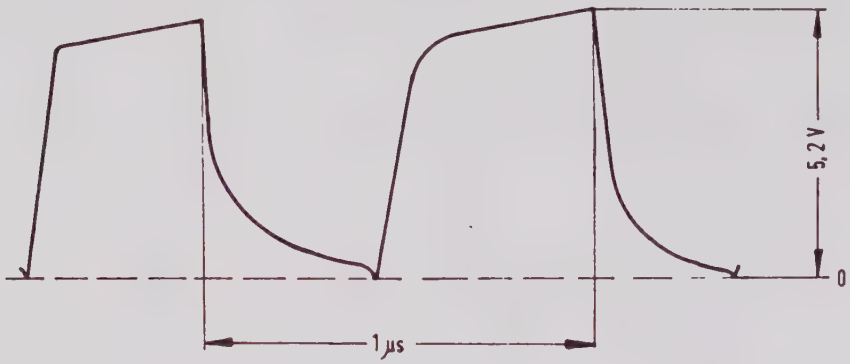

2 Trennstufe z. Normalfrequenz
Standard Frequ. Buffer (11) Bu 1102



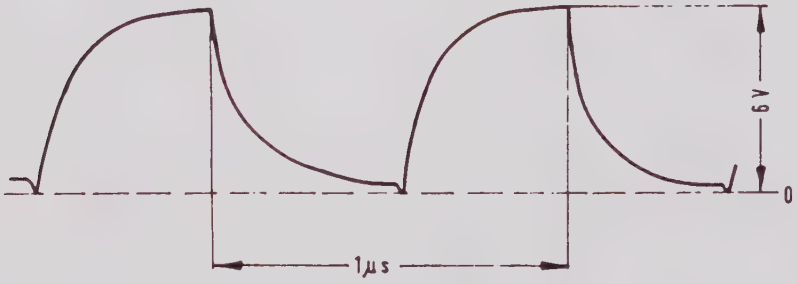

3 Trennstufe z. Normalfrequenz
Standard Frequ. Buffer (11) Bu 1101



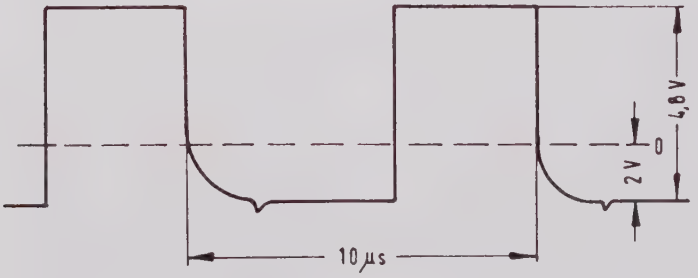
4 Trennstufe z. Normalfrequenz
Standard Frequ. Buffer (11) 241-AV Punkt (point) 3



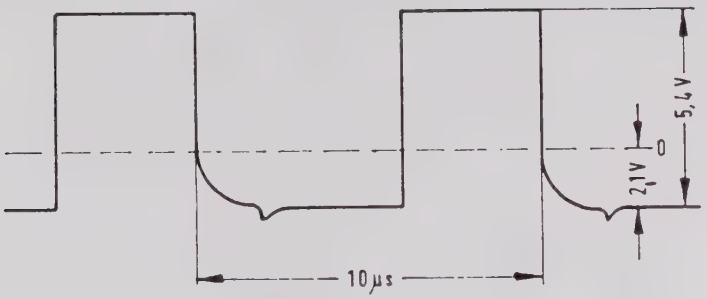

5 Trennstufe z. Normalfrequenz
Standard Frequ. Buffer (11) 241-AR 1 Punkt (point) 2



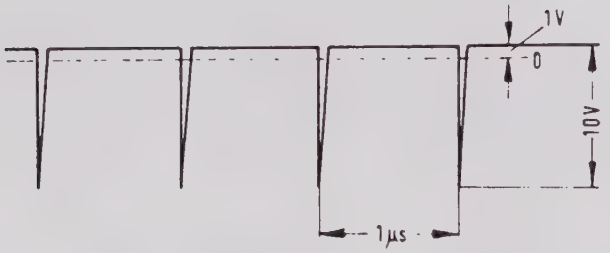

6 2,7-MHz-Quarzoszillator
2,7 MHz Crystal Oscillator (17) 241-K Punkt (point) 1



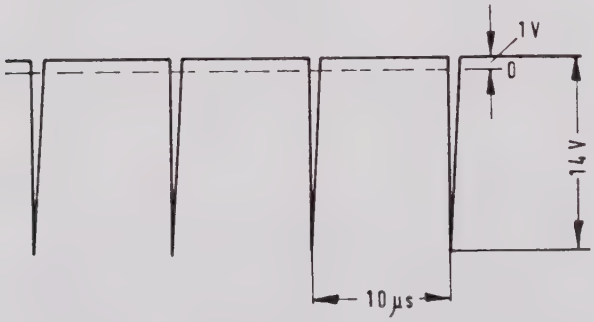
7 Phasenmesser
Phase Meter (14) 241-AR Punkt (point) 11



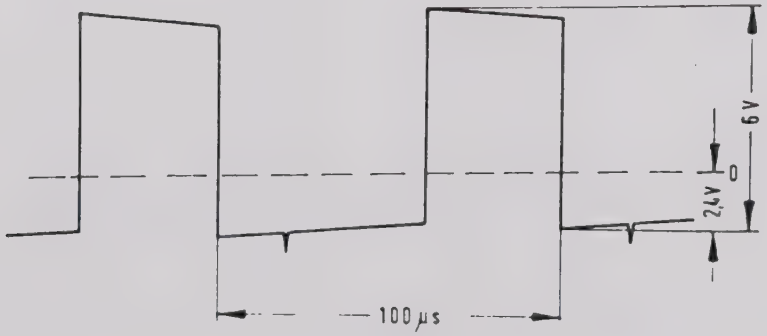

8 Phasenmesser
Phase Meter (14) 241-AR Kollektor (collector) T 1403




9 Phasenmesser
Phase Meter (14) 241-AR Kollektor (collector) T 1405



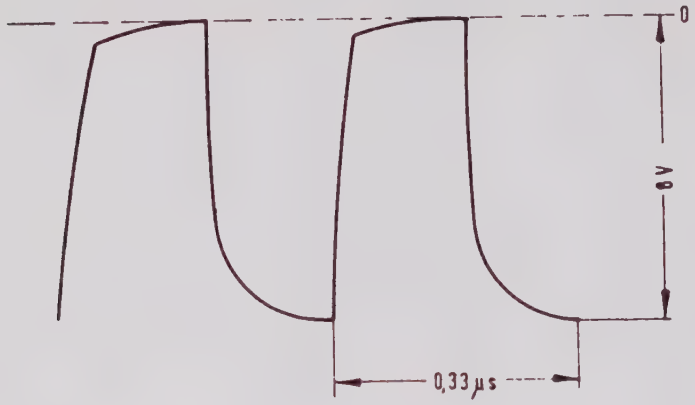

10 Abstimmanzeige
Tuning Indication (19) 241-AA Punkt (point) 1



11 Abstimmanzeige
Tuning Indication

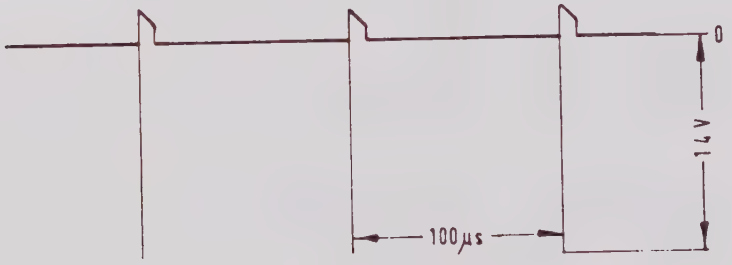
19 241-AA Punkt (point) 2

Interpolationsoszillator auf 0 kHz eingestellt
Interpolation Oscillator set to 0 kHz




12 Abstimmanzeige
Tuning Indication

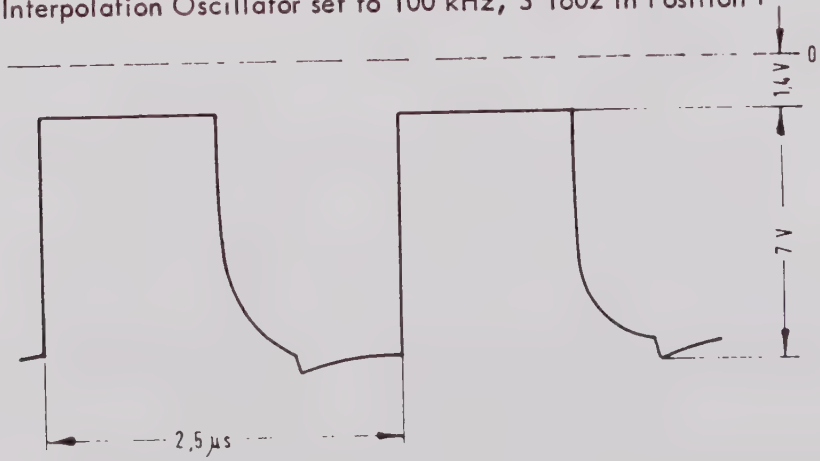
19 241-AA Kollektor (collector) T 1906



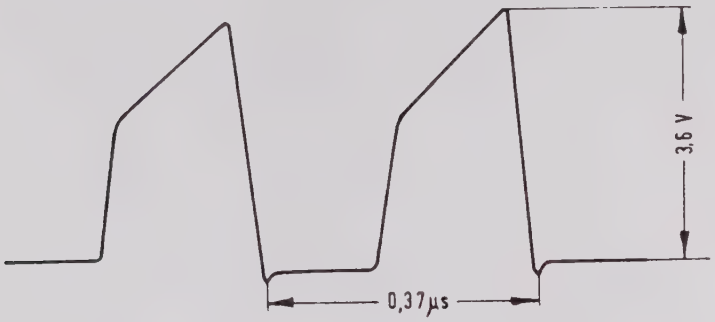

13 Umsetzer
Frequ. Converter

20 400-kHz-Tiefpaß 241-D Punkt 2
400 kHz Low Pass Filter 241-D Point 2

Interpolationsoszillator auf 100 kHz eingestellt, S 1602 in Stellung 1
Interpolation Oscillator set to 100 kHz, S 1602 in Position 1

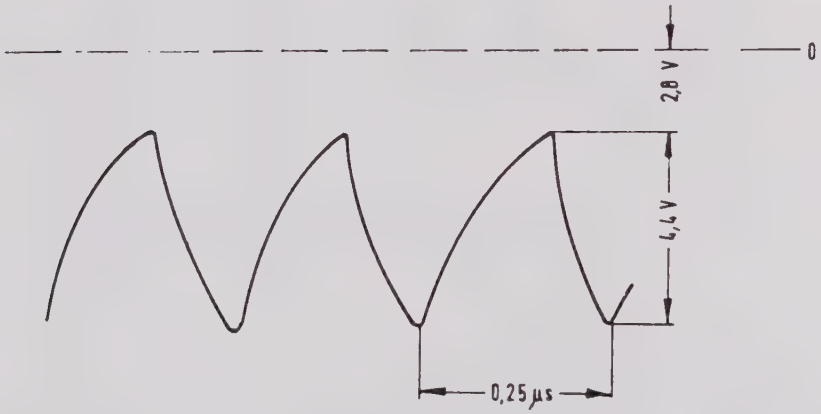


14 Umsetzer
Frequ. Converter (20) 241-E Punkt 2 (Punkt 3 abgelötet!)
Point 2 (Point 3 disconnected)



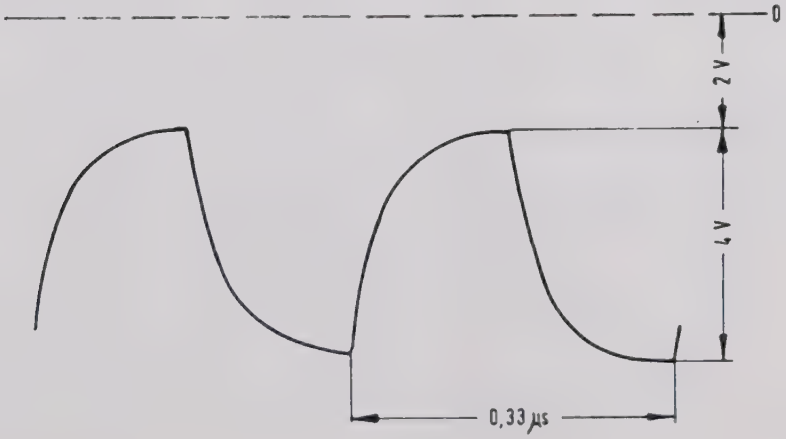

15 Trenn- u. Schaltstufe
Buffer and Switching Stage (21) 241-H Punkt (point) 4

Interpolationsoszillator auf 100 kHz eingestellt, S 1602 in Stellung 1
Interpolation Oscillator set to 100 kHz, S 1602 in Position 1



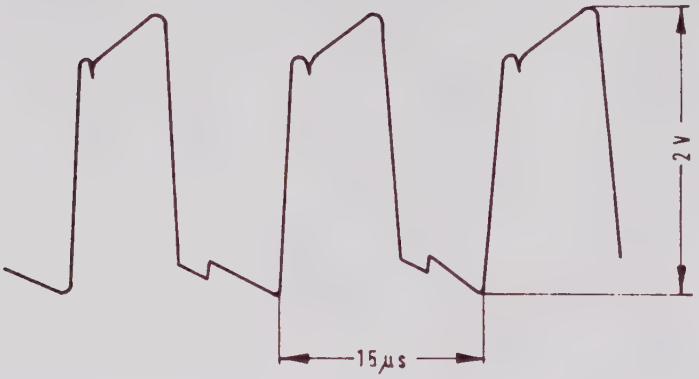

16 Trenn- u. Schaltstufe
Buffer and Switching Stage (21) 241-H Punkt (point) 4

Interpolationsoszillator auf 100 kHz eingestellt, S 1602 in Stellung 2
Interpolation Oscillator set to 100 kHz, S 1602 in Position 2

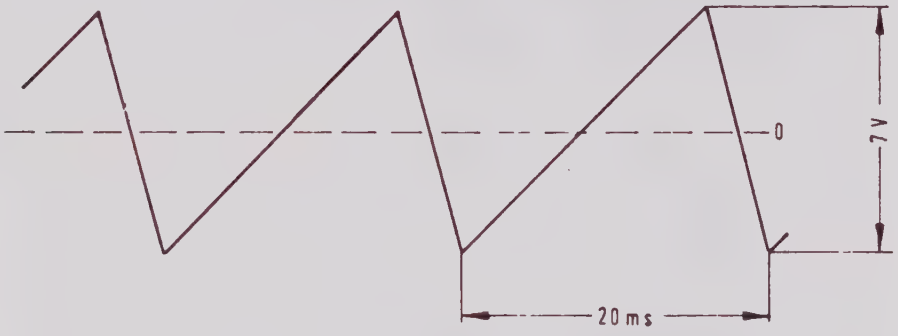


17 Diskriminator für Hilfsoszillator
Auxl. Oscillator Discriminator (6) 241-AD Punkt (point) 4

Grobabstimmoszillator (Coarse Tuning Oscillator) : 0 MHz

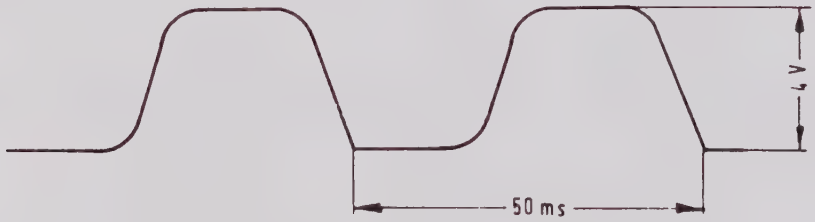



18 Sägezahngenerator
Saw-Tooth Generator (16) 241-AM Bu 1601/1 in Stellung 10
in Position 10

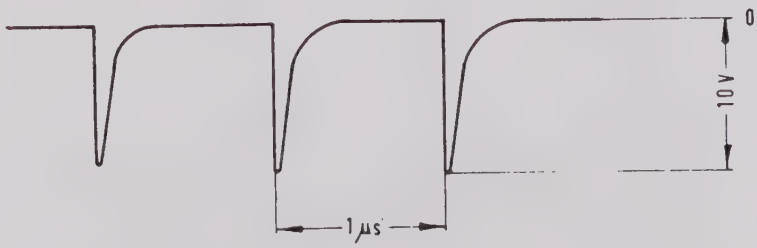



## 6.2 Sendeteil (Generator) PS-5

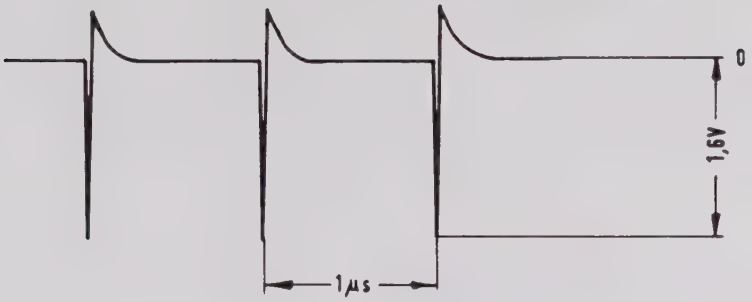
19 Phasenregler
Phase Control (2) 242-E Punkt (point) 5



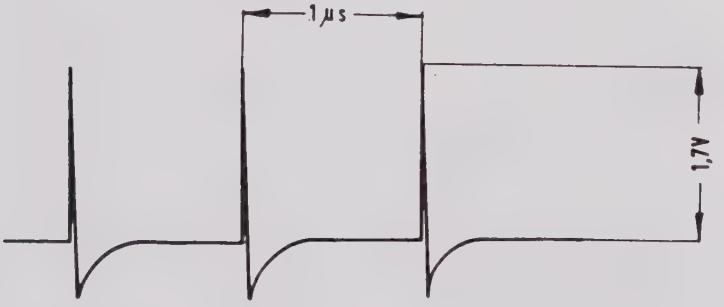

20 Phasenregler
Phase Control (2) 242-E Kollektor (collector) T 202



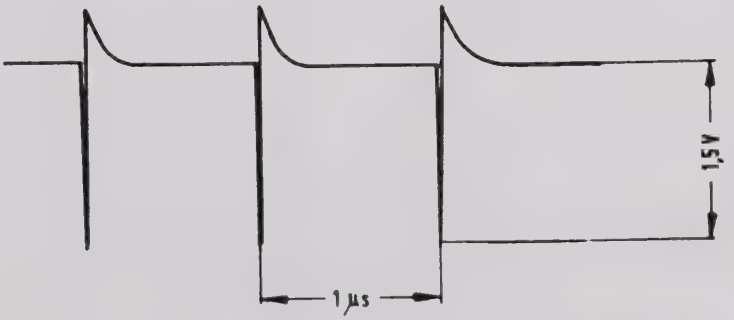
21 Phasenregler (2) 242-E Primärseite Ü 201 Anschluß 1
Phase Control Primary Side Ü 201 Connection 1



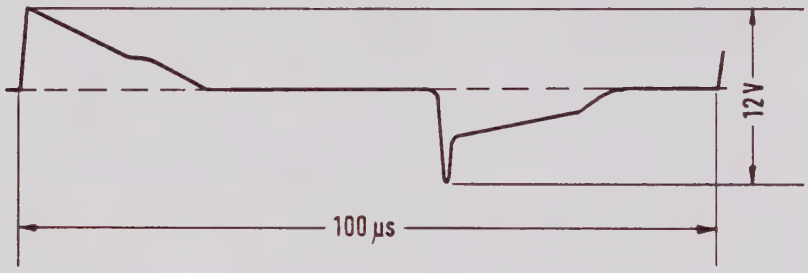

22 Phasenregler (2) 242-E Sekundärseite Ü 201 Anschluß 6
Phase Control Secondary Side Ü 201 Connection 6



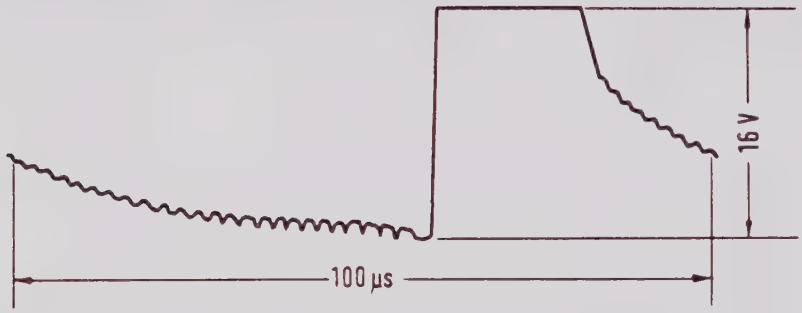

23 Phasenregler (2) 242-E Sekundärseite Ü 201 Anschluß 3
Phase Control Secondary Side Ü 201 Connection 3



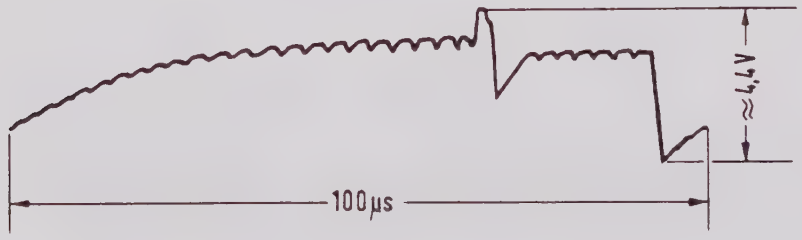
24 Rasteinrichtung / Frequ. Locking Device 10/570 kHz (13) 243-AA Basis T 1302 / Base T 1302



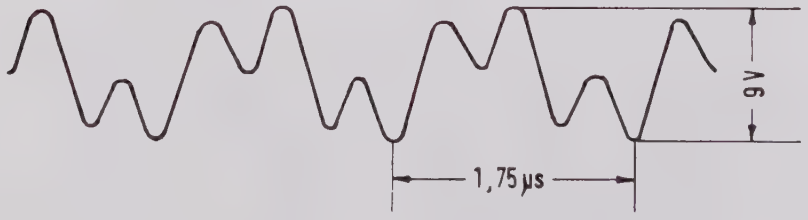

25 Rasteinrichtung / Frequ. Locking Device 10/570 kHz (13) 243-AA Kollektor T 1302 / Collector T 1302



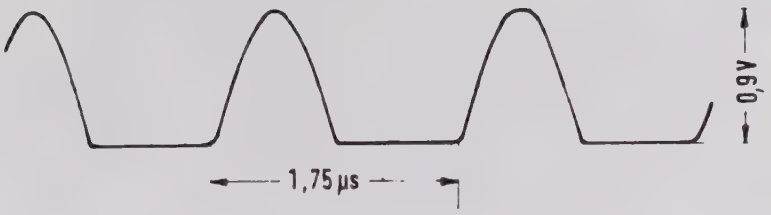

26 Rasteinrichtung / Frequ. Locking Device 10/570 kHz (13) 243-AA Emitter T 1301



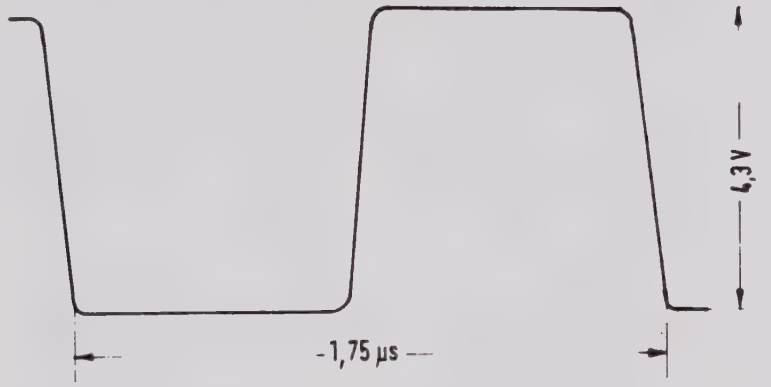

27 Umsetzung / Frequ. Converter 600 kHz/30 kHz (12) 243-P 1 Kollektor T 1210 / Collector T 1210



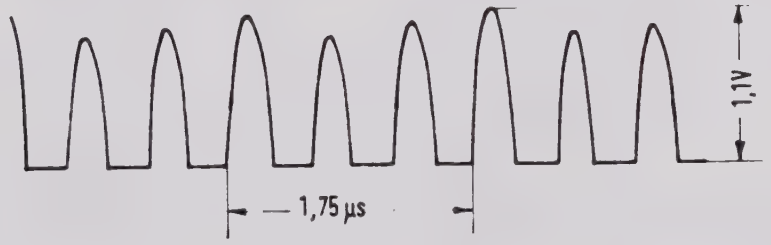
28 Umsetzung
Frequ. Converter 600 kHz/30 kHz (12) 243-P 1 Emitter T 1210



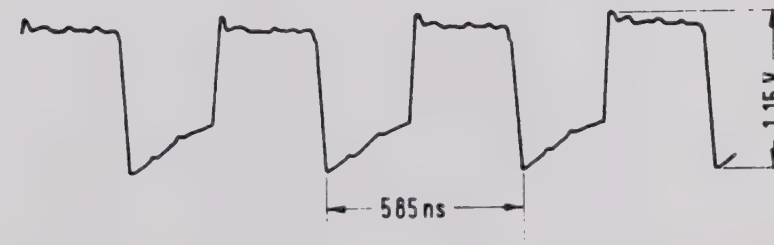

29 Umsetzung
Frequ. Converter 600 kHz/30 kHz (12) 243-P 1 Kollektor T 1209
Collector T 1209



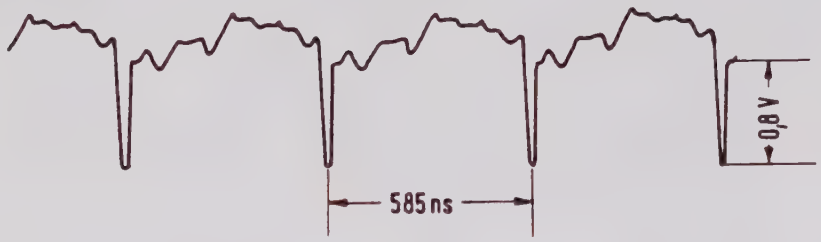

30 Umsetzung
Frequ. Converter 600 kHz/30 kHz (12) 243-0 Emitter T 1205



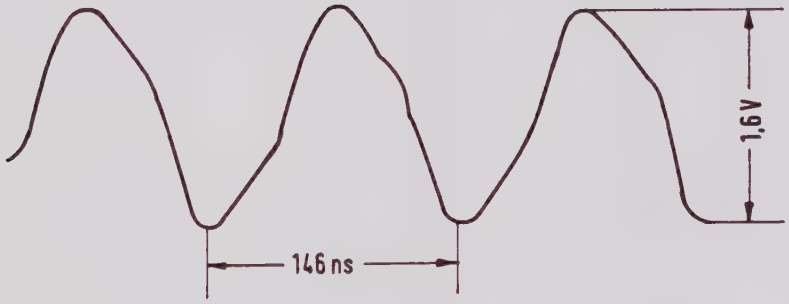

31 Umsetzung
Frequ. Converter 600 kHz/30 kHz (12) 243-0 Basis T 1204
Base T 1204



32 Umsetzung
Frequ. Converter 600 kHz/30 kHz (12) 243-0 Emitter T 1202

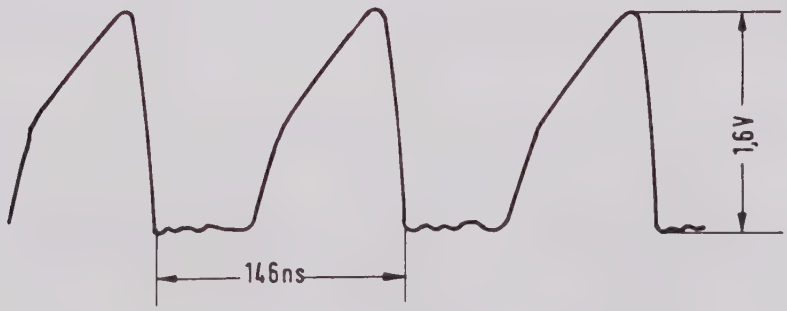



33 Umsetzung
Frequ. Converter 7,44 MHz/600 kHz (11) 243-Y Kollektor T 1105
Collector T 1105




34 Umsetzung
Frequ. Converter 7,44 MHz/600 kHz (11) 243-Y Kollektor T 1102
Collector T 1102

35 Umsetzung
Frequ. Converter 7,44 MHz/600 kHz (11) 243-Y Kollektor T 1101
Collector T 1101



## 7. ADJUSTMENT OF THE OPTICAL PORTION AND THE DRIVE OF THE OSCILLATOR PORTION

These adjustments should normally not be carried out by the customer. If it should, however, be impossible to dispatch the instrument to the factory or a qualified service depot, the adjustment and repair can be carried out according to the following instructions.

### 7.1. Condenser and Lens

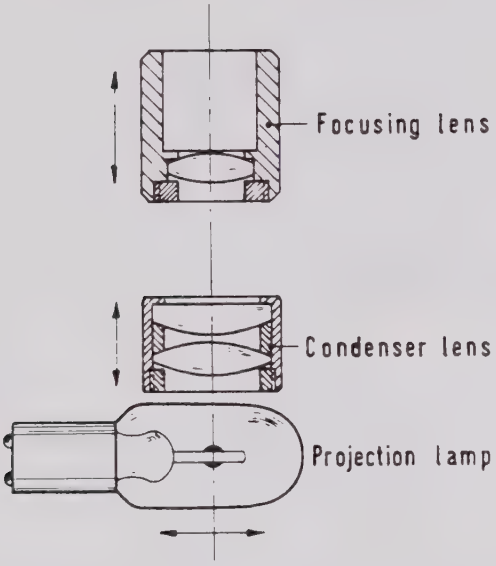



Fig. 71

The lens, condenser and projector lamp are assembled in the drive system as shown in Fig. 71. The focus and the illumination of the transparent scale can be adjusted by shifting the lens and condenser in an axial direction. The die-cast casing of the drive system is provided with two cut-outs, through which the holding screws of the lens and condenser are accessable. If these allen screws are loosened with the corresponding allen key (metric SW 1.5), the lens or condenser can be adjusted with the adjustment tool.

The adjustment tool is knurled under 45° which moves the lens holder when rotated in the cut-out adjacent to the holding screw.

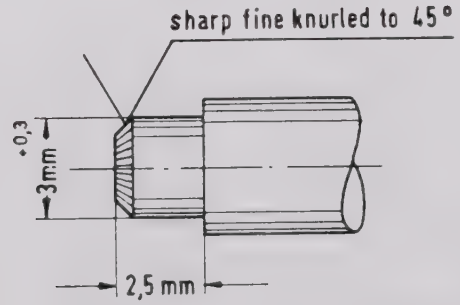



Fig. 72

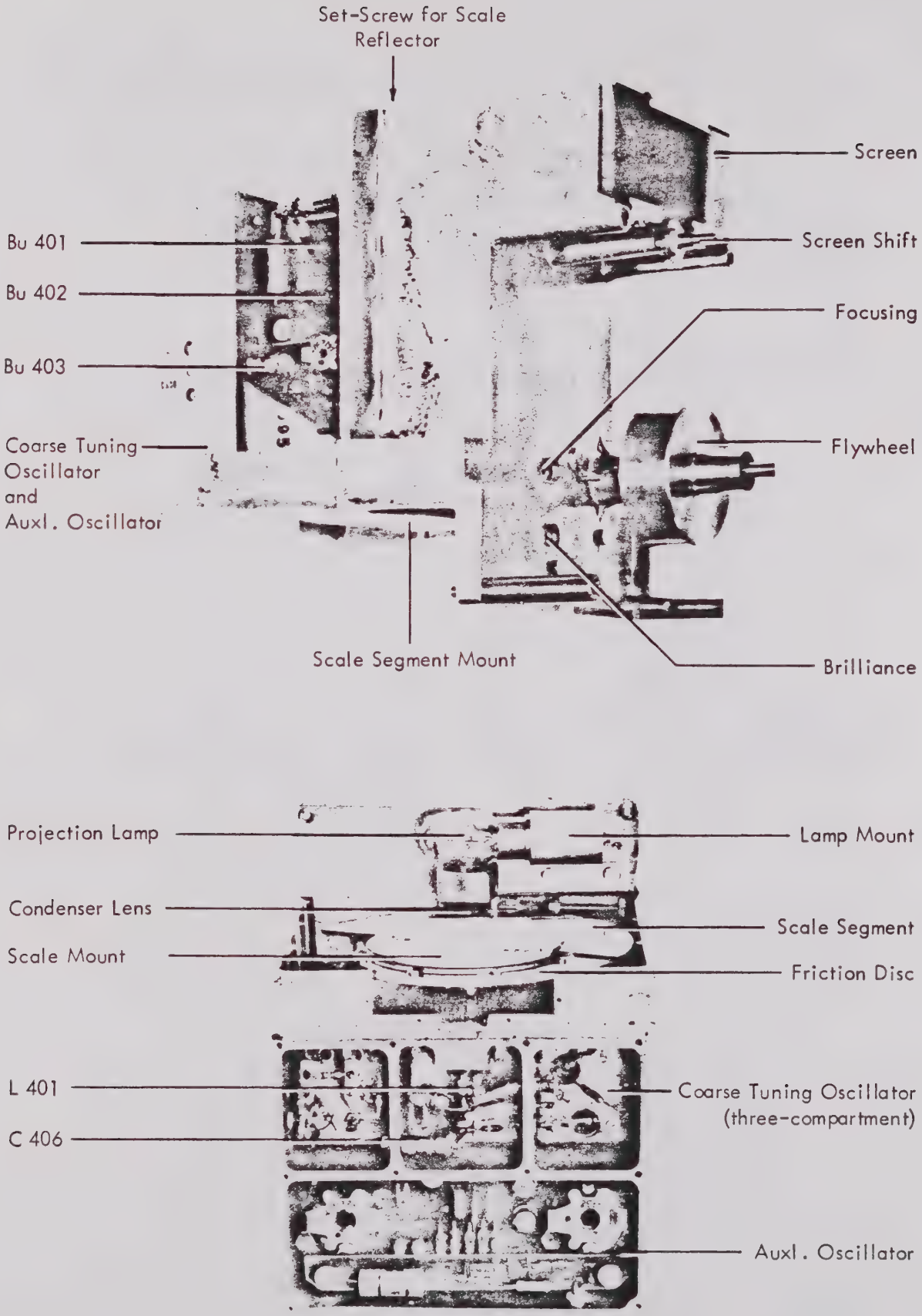



Fig. 73 Coarse Tuning and Auxl. Oscillator with complete drive

The focussing is carried out by adjusting the lens position.
An unequal illumination on the transparent screen can be avoided by adjusting the condenser. If the unequal illumination cannot be cured with the condenser itself, it will be necessary to adjust the projection lamp.
This is described in Section 8.3.

## 7.2. Mirror Adjustment

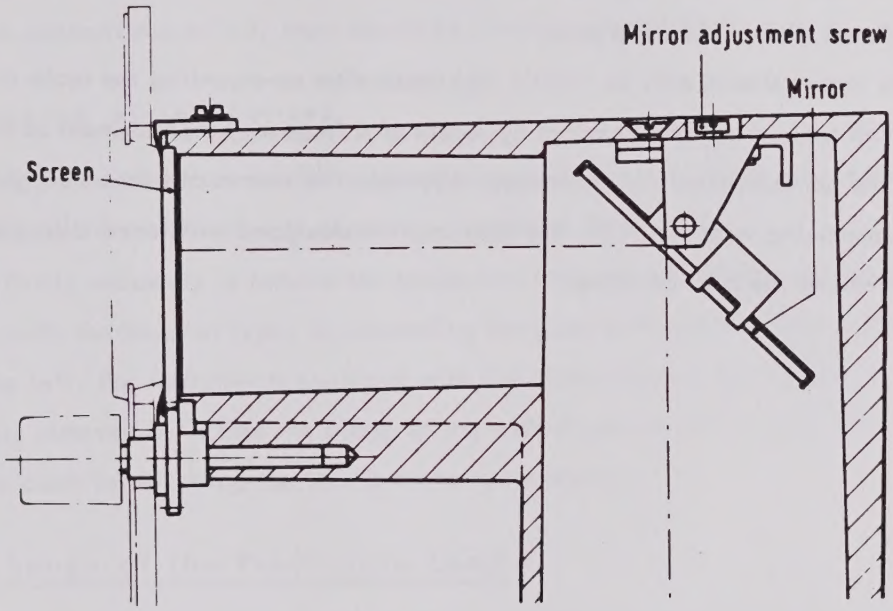



Fig. 74

The mirror can be adjusted in the horizontal and vertical planes. The vertical adjustment is made with the mirror adjustment screw, thus adjusting the length of the projected scale.
It will be necessary to adjust the mirror in horizontal plan if the scale is not truely vertical. To do this, the three Philips screws on the upper side of the casing are loosened and the mirror is adjusted by means of a wooden rod, which has been inserted into the shaft. The 3 screws should be retightened after the adjustment.

## 7.3. Drive Plate

It is recommended that the drive plate should not be removed from the axle, because a re-adjustment would require a high degree of experience. Even the loosening of the drive plate should be avoided.

If, however, a slipping of the drive is observed to be caused by a soiled friction plate, it will be necessary to unscrew the scale disc. This is carried out by loosening the cylinder-head screws and removing the disc.

It is important that the glass disc should not be handled. The friction plate is then cleaned with trichlorethylene.

The screws should only be lightly tightened after re-mounting the scale disc, after which scale should be checked by means of a frequency measurement at the output of the generator and, if necessary, adjusted. The screws can then be tightened.

Commencing with series G, the instrument is equipped with a non-slip geared drive instead of the friction drive.

## 8 INSTRUCTIONS REGARDING MAINTENANCE AND SERVICE

### 8.1. Switch Care

The switch axles of the rotary switches should be lightly oiled if a stiffness is observed at a later date.

It is also recommended to clean the switch contacts roughly once a year with a chamois cloth.

If the contacts are soiled, they should be cleaned with alcohol.

### 8.2. Cleaning of the Lenses

If a brightness reduction of the projection scale is noticed, the condenser lenses should be checked (located directly above the projection lamp).

It is firstly necessary to remove the projection lamp from its holder, which is carried out, with the bayonet type, by depressing the glass bulb and simultaneously rotating to the left. For instruments equipped with the clamp holder, the projection lamp is simply removed by lifting the clamp spring with a screwdriver or coin. The most favourable cloth for cleaning the lens is a chamois material.

### 8.3. Exchange of the Projection Lamp

If it is necessary to exchange a defective or insufficiently bright projection lamp, this is carried out as described in the previous section.

A replacement lamp is provided with the instrument and is to be found in a bracket on the casing of the sawtooth oscillator. If an unequal illumination is observed on the transparent screen, it will be necessary to adjust the position of the lamp. The lamp holder should be adjusted so that the filament directly coincides with the condenser axis. This can be easily seen by observing the transparent screen.

The filament must also be parallel to the surface of the lens, otherwise a equal illumination of the screen will not be achieved. This is achieved by rotating the lamp holder in its bracket. The glass bulb of the lamp should be cleaned with a cloth dampened in alcohol.

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